Proceedings of the Indiana Academy of Science

1917

PROCEEDINGS

OF THE

Indiana Academy of Science

1917

LEE F. BENNETT, EDITOR

INDIANAPOLIS:
WM. B. BURFORD, CONTRACTOR FOR STATE PRINTING AND BINDING
1918

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Feb. 4, 1919

CONTENTS.

CONSTITUTION.

ARTICLE I.

SECTION 1. This association shall be called the Indiana Academy of Science.

SEC. 2. The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science; to promote intercourse between men engaged in scientific work, especially in Indiana; to assist by investigation and discussion in developing and making known the material, educational and other resources and riches of the State; to arrange and prepare for publication such reports of investigation and discussion as may further the aims and objects of the Academy as set forth in these articles.

WHEREAS, The State has undertaken the publication of such proceedings, the Academy will, upon request of the Governor, or one of the several departments of the State, through the Governor, act through its council as an advisory body in the direction and execution of any investigation within its province as stated. The necessary expenses incurred in the prosecution of such investigation are to be borne by the State; no pecuniary gain is to come to the Academy for its advice or direction of such investigation.

The regular proceedings of the Academy as published by the State shall become a public document.

ARTICLE II.

SECTION 1. Members of this academy shall be honorary fellows, fellows, non-resident members or active members.

SEC. 2. Any person engaged in any department of scientific work, or in any original research in any department of science, shall be eligible to active membership. Active members may be annual or life members. Annual members may be elected at any meeting of the Academy; they shall sign the constitution, pay an admission fee of two dollars and thereafter an annual fee of one dollar. Any person who shall at one time contribute fifty dollars to the funds of this Academy may be elected a life

member of the Academy, free of assessment. Non-resident members may be elected from those who have been active members but who have removed from the State. In any case, a three-fourths vote of the members present shall elect to membership. Application for membership in any of the foregoing classes shall be referred to a committee on application for membership, who shall consider such application and report to the Academy before the election.

SEC. 3. The members who are actively engaged in scientific work, who have recognized standing as scientific men, and who have been members of the Academy at least one year, may be recommended for nomination for election as fellows by three fellows or members personally acquainted with their work and character. Of members so nominated a number not exceeding five in one year may, on recommendation of the Executive Committee, be elected as fellows. At the meeting at which this is adopted, the members of the Executive Committee for 1894 and fifteen others shall be elected fellows, and those now honorary members shall bcome honorary fellows. Honorary fellows may be elected on account of special prominence in science, on the written recommendation of two members of the Academy. In any case a three-fourths vote of the members present shall elect.

ARTICLE III.

SECTION 1. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall hold office one year. They shall consist of a President, Vice-President, Secretary, Assistant Secretary, Press Secretary, Editor, and Treasurer, who shall perform the duties usually pertaining to their respective offices and in addition, with the ex-presidents of the Academy, shall constitute an Executive Committee. The President shall, at each annual meeting, appoint two members to be a committee, which shall prepare the programs and have charge of the arrangements for all meetings for one year.

SEC. 2. The annual meeting of the Academy shall be held in the city of Indianapolis within the week following Christmas of each year, unless otherwise ordered by the Executive Committee. There shall also be a summer meeting at such time and place as may be decided upon by the Executive Committee. Other meetings may be called at the discretion of the Executive Committee. The past Presidents, together with the officers

and Executive Committee, shall constitute the council of the Academy, and represent it in the transaction of any necessary business not especially provided for in this constitution, in the interim between general meetings.

SEC. 3. This constitution may be altered or amended at any annual meeting by a three-fourths majority of the attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

BY-LAWS.

1. On motion, any special department of science shall be assigned to a curator, whose duty it shall be, with the assistance of the other members interested in the same department, to endeavor to advance knowledge in that particular department. Each curator shall report at such time and place as the Academy shall direct. These reports shall include a brief summary of the progress of the department during the year preceding the presentation of the report.

2. The President shall deliver a public address on the morning of one of the days of the meeting at the expiration of his term of office.

3. The Press Secretary shall attend to the securing of proper newspaper reports of the meetings and assist the Secretary.

4. No special meeting of the Academy shall be held without a notice of the same having been sent to the address of each member at least fifteen days before such meeting.

5. No bill against the Academy shall be paid without an order signed by the President and countersigned by the Secretary.

6. Members who shall allow their dues to remain unpaid for two years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

7. Ten members shall constitute a quorum for the transaction of business.

8. An Editor shall be elected from year to year. His duties shall be to edit the annual Proceedings. No allowance shall be made to the editor for clerical assistance on account of any one edition of the Pro-

ceedings in excess of fifty ($50) dollars except by special action of the Executive Committee. (Amendment passed December 8, 1917.)

AN ACT TO PROVIDE FOR THE PUBLICATION OF THE REPORTS AND PAPERS OF THE INDIANA ACADEMY OF SCIENCE.

(Approved March 11, 1895.)

WHEREAS, The Indiana Academy of Science, a chartered scientific association, has embodied in its constitution a provision that it will, upon the request of the Governor, or of the several departments of the State government, through the Governor, and through its council as an advisory board, assist in the direction and execution of any investigation within its province without pecuniary gain to the Academy, provided only that the necessary expenses of such investigation are borne by the State; and,

WHEREAS, The reports of the meetings of said Academy, with the several papers read before it, have very great educational, industrial and economic value, and should be preserved in permanent form; and,

WHEREAS, The Constitution of the State makes it the duty of the General Assembly to encourage by all suitable means intellectual, scientific and agricultural improvement; therefore,

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana,* That hereafter the annual reports of the meetings of the Indiana Academy of Science, beginning with the report for the year 1894, including all papers of scientific or economic value, presented at such meetings, after they shall have been edited and prepared for publication as hereinafter provided, shall be published by and under the direction of the Commissioners of Public Printing and Binding.

SEC. 2. Said reports shall be edited and prepared for publication without expense to the State, by a corps of editors to be selected and appointed by the Indiana Academy of Science, who shall not, by reason of such service, have any claim against the State for compensation. The form, style of binding, paper, typography and manner and extent of illustration of such reports shall be determined by the editors, subject to the approval of the Commissioners of Public Printing and Stationery. Not less than 1,500 nor more than 3,000 copies of each of said reports shall be

published, the size of the edition within said limits to be determined by the concurrent action of the editors and the Commissioners of Public Printing and Stationery: *Provided,* That not to exceed six hundred dollars ($600) shall be expended for such publication in any one year, and not to extend beyond 1896: *Provided,* That no sums shall be deemed to be appropriated for the year 1894.

SEC. 3. All except three hundred copies of each volume of said reports shall be placed in the custody of the State Librarian, who shall furnish one copy thereof to each public library in the State, one copy to each university, college or normal school in the State, one copy to each high school in the State having a library, which shall make application therefor, and one copy to such other institutions, societies or persons as may be designated by the Academy through its editors or its council. The remaining three hundred copies shall be turned over to the Academy to be disposed of as it may determine. In order to provide for the preservation of the same it shall be the duty of the Custodian of the State House to provide and place at the disposal of the Academy one of the unoccupied rooms of the State House, to be designated as the office of the Academy of Science, wherein said copies of said reports belonging to the Academy, together with the original manuscripts, drawings, etc., thereof can be safely kept, and he shall also equip the same with the necessary shelving and furniture.

SEC. 4. An emergency is hereby declared to exist for the immediate taking effect of this act, and it shall therefore take effect and be in force from and after its passage.

APPROPRIATION FOR 1917-1918.

The appropriation for the publication of the proceedings of the Academy during the years 1916 and 1917 was increased by the Legislature in the General Appropriation bill, approved March 8, 1915. The Act making appropriation for the years 1917-1918 and 1918-1919 was approved March 6, 1917. That portion of the law fixing the amount of the appropriation for the Academy is herewith given in full.

For the Academy of Science: For the printing of the proceedings of the Indiana Academy of Science twelve hundred dollars: *Provided,* That any unexpended balance in 1916 shall be available for 1917 and that any unexpended balance in 1917 shall be available in 1918.

PUBLIC OFFENSES—HUNTING WILD BIRDS—PENALTY.

(Approved March 15, 1913.)

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana,* That section six (6) of the above entitled act be amended to read as follows: Section 6. That section six hundred two (602) of the above entitled act be amended to read as follows: Section 602. It shall be unlawful for any person to kill, trap or possess any wild bird, or to purchase or offer the same for sale, or to destroy the nest or eggs of any wild bird, except as otherwise provided in this section. But this section shall not apply to the following named game birds: The Anatidae, commonly called swans, geese, brant, river and sea duck; the Rallidae, commonly known as rails, coots, mud-hens and gallinules; the Limicolae, commonly known as shore birds, plovers, surf birds, snipe, woodcock, sandpipers, tattlers and curlews; the Gallinae, commonly called wild turkeys, grouse, prairie chickens, quails, and pheasants; nor to English or European house sparrows, blackbirds, crows, hawks or other birds of prey. Nor shall this section apply to any person taking birds or their nests or eggs for scientific purposes under permit as provided in the next section. Any person violating the provisions of this section shall, on conviction, be fined not less than ten dollars ($10.00) nor more than fifty dollars ($50.00).

INDIANA ACADEMY OF SCIENCE.

OFFICERS, 1918.

PRESIDENT,

E. B. WILLIAMSON.

VICE-PRESIDENT,

CHARLES STOLTZ.

SECRETARY,

HOWARD E. ENDERS.

ASSISTANT SECRETARY,

PHILIP A. TETRAULT.

PRESS SECRETARY,

FRANK B. WADE.

TREASURER,

WILLIAM M. BLANCHARD.

EDITOR,

LEE F. BENNETT.

EXECUTIVE COMMITTEE:

ARTHUR, J. C.,
BENNETT, L. F.,
BIGNEY, A. J.,
BLANCHARD, W. M.,
BLATCHLEY, W. S.,
BRANNER, J. C.,
BURRAGE, SEVERANCE,
BUTLER, AMOS W.,
COGSHALL, W. A.,
COULTER, JOHN M.,
COULTER, STANLEY,
CULBERTSON, GLENN,
DRYER, CHAS. R.,
EIGENMANN, C. H.,
ENDERS, HOWARD E.,
EVANS, P. N.,
FOLEY, A. L.,
HAY, O. P.,
HESSLER, ROBERT,
JORDAN, D. S.,
MCBETH, W. A.,
MEES, CARL L.,
MOENKHAUS, W. J.,
MOTTIER, DAVID M.,
MENDENHALL, T. C.,
NAYLOR, JOSEPH P.,
NOYES, W. A.,
STOLTZ, CHARLES,
TETRAULT, P. A.,
WADE, F. B.,
WALDO, C. A.,
WILEY, H. W.,
WILLIAMSON, E. B.,
WRIGHT, JOHN S.

CURATORS:

BOTANY .... J. C. ARTHUR.
ENTOMOLOGY .... W. S. BLATCHLEY.
HERPETOLOGY, MAMMALOGY, ORNITHOLOGY .... A. W. BUTLER.
ICHTHYOLOGY .... C. H. EIGENMANN.

Committees Academy of Science, 1918.

Program.

C. C. Deam, Bluffton

Frank B. Wade, Shortridge High School, Indianapolis

John S. Wright, Indianapolis

Nominations.

Stanley Coulter, Lafayette

W. J. Moenkhaus, Bloomington

J. P. Naylor, Greencastle

State Library.

W. S. Blatchley, 1558 Park Avenue, Indianapolis

A. L. Foley, Bloomington

Amos W. Butler, State House, Indianapolis

Biological Survey.

Herbert S. Jackson, Agr. Experiment Station, West Lafayette

Richard M. Holman, Crawfordsville

M. S. Markle, Richmond

Will Scott, Indiana University, Bloomington

Distribution of Proceedings.

Howard E. Enders, West Lafayette

Wm. M. Blanchard, Greencastle

U. O. Cox, State Normal, Terre Haute

George Osner, West Lafayette

Membership.

F. M. Andrews, Bloomington

M. L. Fisher, West Lafayette

Mason L. Weems, Valparaiso

Auditing.

Glenn Culbertson, Hanover

Rollo Ramsey, Bloomington

Relation of the Academy to the State.

R. W. McBride, 1239 State Life Building, Indianapolis

Glenn Culbertson, Hanover

H. E. Barnard, State House, Indianapolis

John S. Wright, 3718 Penn. St., Indianapolis

W. W. Woollen, 1628 Penn. St., Indianapolis

Publication of Proceedings.

Lee F. Bennett, 825 Laporte Avenue, Valparaiso

Robert Hessler, Logansport.

George N. Hoffer, West Lafayette

R. R. Hyde, Terre Haute

James Brown, 5372 E. Washington St., Indianapolis

Advisory Council.

John S. Wright

R. W. McBride

Glenn Culbertson

Stanley Coulter

Wilbur Cogshall

OFFICERS OF THE INDIANA ACADEMY OF SCIENCE.

Years.	President.	Secretary.	Asst. Secretary.	Press Secretary.	Treasurer.
1885–1886	David S. Jordan	Amos W. Butler	....	....	O. P. Jenkins.
1886–1887	John M. Coulter	Amos W. Butler	....	....	O. P. Jenkins.
1887–1888	J. P. D. John*	Amos W. Butler	....	....	O. P. Jenkins.
1888–1889	John C. Branner	Amos W. Butler	....	....	O. P. Jenkins.
1889–1890	T. C. Mendenhall	Amos W. Butler	....	....	O. P. Jenkins.
1890–1891	O. P. Hay	Amos W. Butler	....	....	O. P. Jenkins.
1891–1892	J. L. Campbell*	Amos W. Butler	....	....	C. A. Waldo.
1892–1893	J. C. Arthur	Amos W. Butler	Stanley Coulter W. W. Norman	....	C. A. Waldo.
1893–1894	W. A. Noyes	C. A. Waldo	W. W. Norman	....	W. P. Shannon.
1894–1895	A. W. Butler	John S. Wright	A. J. Bigney	....	W. P. Shannon.
1895–1896	Stanley Coulter	John S. Wright	A. J. Bigney	....	W. P. Shannon.
1896–1897	Thomas Gray*	John S. Wright	A. J. Bigney	....	W. P. Shannon.
1897–1898	C. A. Waldo	John S. Wright	A. J. Bigney	Geo. W. Benton	J. T. Scovell.*
1898–1899	C. H. Eigenmann	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1899–1900	D. W. Dennis*	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1900–1901	M. B. Thomas*	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1901–1902	Harvey W. Wiley	John S. Wright	Donaldson Bodine*	Geo. W. Benton	J. T. Scovell.
1902–1903	W. S. Blatchley	John S. Wright	Donaldson Bodine	G. A. Abbott	W. A. McBeth.
1903–1904	C. L. Mees	John S. Wright	J. H. Ransom	G. A. Abbott	W. A. McBeth.

OFFICERS—Continued.

Years.	President.	Secretary.	Asst. Secretary.	Press Secretary.	Treasurer.
1904–1905	John S. Wright	Lynn B. McMullen	J. H. Ransom	G. A. Abbott	W. A. McBeth.
1905–1906	Robert Hessler	Lynn B. McMullen	J. H. Ransom	Charles R. Clark	W. A. McBeth.
1906–1907	D. M. Mottier	Lynn B. McMullen	J. H. Ransom	G. A. Abbott	W. A. McBeth.
1907–1908	Glenn Culbertson	J. H. Ransom	A. J. Bigney	G. A. Abbott	W. A. McBeth.
1908–1909	A. L. Foley	J. H. Ransom	A. J. Bigney	G. A. Abbott	W. A. McBeth.
1909–1910	P. N. Evans	Geo. W. Benton	A. J. Bigney	John W. Woodhams	W. J. Moenkhaus.
1910–1911	C. R. Dryer	A. J. Bigney	E. B. Williamson	Milo H. Stuart	W. J. Moenkhaus.
1911–1912	J. P. Naylor	A. J. Bigney	E. B. Williamson	Milo H. Stuart	W. J. Moenkhaus.
1912–1913	Donaldson Bodine*	A. J. Bigney	C. M. Smith	F. B. Wade	W. J. Moenkhaus.
1913–1914	Severance Burrage	A. J. Bigney	Howard E. Enders	F. B. Wade	W. A. Cogshall.
1914–1915	Wilbur A. Cogshall	A. J. Bigney	Howard E. Enders	F. B. Wade	Wm. M. Blanchard.
1915–1916	A. J. Bigney	Howard E. Enders	E. B. Williamson	F. B. Wade	Wm. M. Blanchard.
1916–1917	W. J. Moenkhaus	Howard E. Enders	P. A. Tetrault	F. B Wade	Wm M. Blanchard.
1917–1918	E. B. Williamson	Howard E. Enders	P. A. Tetrault	F. B. Wade	Wm. M. Blanchard.

*Deceased.

MEMBERS.*

FELLOWS.

Anderson, H. W., Urbana, Ill. . . . . †1912
Department of Botany, University of Illinois.
Botany.

Andrews, F. M., 901 E. 10th Street, Bloomington 1911
Associate Professor of Botany, Indiana University.
Plant Physiology, Botany.

Arthur, Joseph C., 915 Columbia St., Lafayette 1893
Professor (Retired) of Vegetable Physiology and Pathology, Purdue University.
Botany.

Badertscher, J. A., Bloomington 1917
Professor of Anatomy, Indiana University.
Anatomy.

Barnard, H. E., Room 20 State House, Indianapolis 1910
Chemist to Indiana State Board of Health, State Food Administrator.
Chemistry, Sanitary Science, Pure Foods.

Beede, Joshua W., 404 W. 38th St., Austin, Texas 1906
Bureau of Economic Geology and Technology, Univ. Texas.
Geology.

Behrens, Charles A., West Lafayette, Ind 1917
Professor of Bacteriology, Purdue University.
Bacteriology.

Bennett, Lee F., 825 Laporte Ave., Valparaiso 1916
Professor of Geology and Zoology, Valparaiso University.
Geology, Zoology.

* Every effort has been made to obtain the correct address and occupation of each member, and to learn in what line of science he is interested. The first line contains the name and address; the second line the occupation; the third line the branch of science in which he is interested. The omission of an address indicates that mail addressed to the last printed address was returned as uncalled for. Information as to the present address of members so indicated is requested by the secretary. The custom of dividing the list of members has been followed.

† Date of election.

Benton, George W., 100 Washington Square, New York, N. Y...... 1896
Editor in Chief, American Book Company.

Bigney, Andrew J., Moores Hill, Ind............................ 1897
Professor of Biology and Geology, Moores Hill College.
Biology, Geology.

Bitting, Mrs. Katherine Golden, Washington, D. C............... 1895
Miscroscopic Expert, Pure Food, National Canners Laboratory.
Botany.

Blanchard, William M., 1008 S. College Ave., Greencastle, Ind...... 1914
Professor of Chemistry, DePauw University, Greencastle, Ind.
Organic Chemistry.

Blatchley, W. S., 1558 Park Ave., Indianapolis................... 1893
Naturalist.
Botany, Entomology, and Geology.

Breeze, Fred J., Hunter Avenue, Bloomington........ 1910
Graduate School, Indiana University.
Geography.

Bruner, Henry Lane, 324 S. Ritter Ave., Indianapolis............. 1899
Professor of Biology, Butler College.
Comparative Anatomy, Zoology.

Bryan, William Lowe, Bloomington............................. 1914
President Indiana University.
Psychology.

Butler, Amos W., 52 Downey Ave., Irvington................... 1893
Secretary, Indiana Board of State Charities.
Vertebrate Zoology, Anthropology, Sociology.

Cogshall, Wilbur A., 423 S. Fess Ave., Bloomington.............. 1906
Associate Professor of Astronomy, Indiana University.
Astronomy.

Coulter, Stanley, 213 S. Ninth St., Lafayette.................... 1893
Dean School of Science, Purdue University.
Botany, Forestry.

Cox, Ulysses O., P. O. Box 81, Terre Haute.................... 1908
Head Department Zoology and Botany, Indiana State Normal.
Botany, Zoology.

Culbertson, Glenn, Hanover.................................... 1899
Chair Geology, Physics and Astronomy, Hanover College.
Geology.

Cumings, Edgar Roscoe, 327 E. Second St., Bloomington.......... 1906
Professor of Geology, Indiana University.
Geology, Paleontology.

Deam, Charles C., Bluffton.................................... 1910
Druggist, Botanist, State Forester.
Botany.

Dryer, Charles R., Oak Knoll, Fort Wayne, or Terre Haute....... 1897
Geography.

Dutcher, J. B., 1212 Atwater St., Bloomington.................. 1914
Associate Professor of Physics, Indiana University.
Physics.

Eigenmann, Carl H., 630 Atwater St., Bloomington.............. 1893
Professor of Zoology, Dean of Graduate School, Indiana University.
Embryology, Degeneration, Heredity, Evolution and Distribution of American Fish.

Enders, Howard Edwin, 107 Fowler Ave., Lafayette.............. 1912
Professor of Zoology, Purdue University.
Zoology.

Evans, Percy Norton, 302 Waldron Street, West Lafayette...... 1901
Director of Chemical Laboratory, Purdue University.
Chemistry.

Foley, Arthur L., Bloomington................................. 1897
Head of Department of Physics, Indiana University.
Physics.

Golden, M. J., West Lafayette................................. 1899
Formerly Director of Laboratories of Practical Mechanics, Purdue University.
Mechanics.

Hathaway, Arthur S., 2206 N. Tenth St., Terre Haute............ 1895
Professor of Mathematics, Rose Polytechnic Institute.
Mathematics, Physics.

Hessler, Robert, Logansport.................................. 1899
Physician.
Biology.

Hoffer, George N., Littleton St., West Lafayette................. 1913
Federal Agent, Purdue University Experiment Station.

Hufford, Mason E., Bloomington.................................. 1916
Physics.

Hurty, J. N., Indianapolis...................................... 1910
Secretary, Indiana State Board of Health.
Sanitary Science, Vital Statistics, Eugenics.

Hyde, Roscoe Raymond, 636 Chestnut Street, Terre Haute........ 1909
Assistant Professor Physiology and Zoology, Indiana State Normal.
Zoology, Physiology, Bacteriology.

Kenyon, Alfred Monroe, 315 University St., West Lafayette...... 1914
Professor of Mathematics, Purdue University.
Mathematics.

Kern, Frank D., State College Pa.............................. 1912
Professor of Botany, Pennsylvania State College.
Botany.

Koch, Edward W., Eli Lilly Co., Indianapolis.................... 1917
Department of Research, Eli Lilly Co.
Physiology.

Logan, Wm. N., 320 S. Fess Ave., Bloomington.................. 1917
Professor of Economic Geology, Indiana University.
Geology.

McBeth, William A., 1905 N. Eighth St., Terre Haute........... 1904
Assistant Professor of Geography, Indiana Normal School.
Geography, Geology, Scientific Agriculture.

McBride, Robert W., 1239 State Life Building, Indianapolis....... 1916
Lawyer.

Middleton, A. R., 629 University St., West Lafayette............. 1908
Professor of Chemistry, Purdue University.
Chemistry.

Moenkhaus, William J., 501 Fess Ave., Bloomington.............. 1901
Professor of Physiology, Indiana University.
Physiology.

Morrison, Edwin, 80 S. W. Seventh St., Richmond.............. 1915
Professor of Physics, Earlham College.
Physics and Chemistry.

Mottier, David M., 215 Forest Place, Bloomington............... 1893
Professor of Botany, Indiana University.
Morphology, Cytology.

Naylor, J. P., Greencastle...................................... 1903
Professor of Physics, DePauw University.
Physics, Mathematics.

Payne, F., 620 S. Fess Ave., Bloomington....................... 1916
Associate Professor of Zoology, Indiana University.
Cytology and Embryology.

Pohlman, Augustus G., 16 Yale Ave., University City, St. Louis, Mo. 1911
Professor of Anatomy.
Embryology, Comparative Anatomy.

Ramsey, Rolla R., 615 E. Third St., Bloomington................. 1906
Associate Professor of Physics, Indiana University.
Physics.

Ransom, James H., 323 University St., West Lafayette........... 1902
Professor of General Chemistry, Purdue University.
General Chemistry, Organic Chemistry, Teaching.

Rettger, Louis J., 31 Gilbert Ave., Terre Haute.................. 1896
Professor of Physiology, Indiana State Normal.
Animal Physiology.

Rothrock, David A., Bloomington................................ 1906
Professor of Mathematics, Indiana University.
Mathematics.

Schockel, Barnard, Terre Haute................................. 1917
Professor of Physical Geography, State Normal School.

Scott, Will, 731 Atwater St., Bloomington...................... 1911
Assistant Professor of Zoology, Indiana University.
Zoology, Lake Problems.

Shannon, Charles W., 518 Lahoma Ave., Norman, Okla........... 1912
With Oklahoma State Geological Survey.
Soil Survey, Botany.

Smith, Albert, University St., West Lafayette.................. 1908
Professor of Structural Engineering.
Physics, Mechanics.

Smith, Charles Marquis, 152 Sheetz St., West Lafayette.......... 1912
Professor of Physics, Purdue University.
Physics.

Stone, Winthrop E., Lafayette.................................. 1893
President of Purdue University.
Chemistry.

Van Hook, James M., 939 N. College Ave., Bloomington.......... 1911
Assistant Professor of Botany, Indiana University.
Botany.

Wade, Frank Bertram, 1039 W. Twenty-seventh St., Indianapolis.. 1914
Head of Chemistry Department, Shortridge High School.
Chemistry, Physics, Geology, and Mineralogy.

Waterman, Luther D., 226 Pratt St., Indianapolis............... 1916
Physician.

Williamson, E. B., Bluffton.................................... 1914
Cashier, The Wells County Bank.
Dragonflies.

Woollen, William Watson, Indianapolis......................... 1908
Lawyer.
Birds and Nature Study.

Wright, John S., care Eli Lilly Co., Indianapolis................. 1894
Manager of Advertising Department, Eli Lilly Co.
Botany.

NON-RESIDENT MEMBERS AND FELLOWS.

Abbott, G. A., Grand Forks, N. Dak., Fellow.................... 1908
Professor of Chemistry, University of North Dakota.
Chemistry.

Aley, Robert J., Orono, Me., Fellow............................ 1908
President of University of Maine.
Mathematics and General Science.

Branner, John Casper, Stanford University, Calif.
President Emeritus of Stanford University.
Geology.

Brannon, Melvin A., President University of Idaho, Moscow, Idaho.
Professor of Botany.
Plant Breeding.

Burrage, Severance, Waco, Texas.................................. 1898
United States Public Health Work.

Campbell, D. H., Stanford University, Calif.
Professor of Botany, Stanford University.
Botany.

Clark, Howard Walton, U. S. Biological Station, Fairport, Iowa.
Scientific Assistant U. S. Bureau of Fisheries.
Botany, Zoology.

Cook, Mel T., New Brunswick, N. J., Fellow.................... 1902
Plant Pathologist, New Jersey Experiment Station.
Botany, Plant Pathology, Entomology.

Coulter, John M., University of Chicago, Chicago, Ill., Fellow.... 1893
Head Department of Botany, Chicago University.
Botany.

Davis, B. M., Oxford, Ohio.
Professor of Agricultural Education.
Miami University.

Duff, A. Wilmer, 43 Harvard St., Worcester, Mass.
Professor of Physics, Worcester Polytechnic Institute.
Physics.

Evermann, Barton Warren, Director Museum.
California Academy of Science, Golden Gate Park, San Francisco, Cal.
Zoology.

Fiske, W. A., Los Angeles, Cal., Occidental College.

Gilbert, Charles H., Stanford University, California.
Professor of Zoology, Stanford University.
Ichthyology.

Goss, William Freeman M., 61 Broadway, N. Y., Fellow............ 1893
President The Railway Car Manufacturers Association.

Greene, Charles Wilson, 814 Virginia Ave., Columbia, Mo.
Professor of Physiology and Pharmacology, University of Missouri.
Physiology, Zoology.

Hargitt, Chas. W., 909 Walnut Ave., Syracuse, N. Y.
Professor of Zoology and Director of the Laboratories Syracuse University.
Hygiene, Embryology, Eugenics, Animal Behavior.

Hay, Oliver Perry, U. S. National Museum, Washington, D. C.
Research Associate, Carnegie Institute of Washington.
Vertebrate Paleontology, especially that of the Pleistocene Epoch.

Huston, H. A., New York City, Fellow.......................... 1893
Secretary, German Kali Works.

Jenkins, Oliver P., Stanford University, California.
Professor of Physiology, Stanford University.
Physiology, Histology.

Jordan, David Starr, Stanford University, California.
Chancellor Emeritus of Stanford University.
Fish, Eugenics, Botany, Evolution.

Kingsley, J. S., University of Illinois, Urbana, Ill.
Professor of Zoology.
Zoology.

KleinSmid von, R. B., President Univ. of Arizona, Tucson, Ariz.

Knipp, Charles T., 915 W. Nevada St., Urbana, Illinois.
Professor of Experimental Physics, University of Illinois.
Physics, Discharge of Electricity through Gases.

Marsters, V. F., Kansas City, Missouri, Care of C. N. Gould, Fellow 1893
Geologist.

McDougal, Daniel Trembly, Tucson, Arizona.
Director, Department of Botanical Research, Carnegie Institute, Washington, D. C.
Botany.

McMullen, Lynn Banks, State Normal School, Valley City, N. D.
Head Science Department and Vice-Pres. State Normal School.
Physics, Chemistry.

Mendenhall, Thomas Corwin, Ravenna, Ohio.
Retired.
Physics, "Engineering," Mathematics, Astronomy.

Miller, John Anthony, Swarthmore, Pa., Fellow.................. 1904
Professor of Mathematics and Astronomy, Swarthmore College.
Astronomy, Mathematics.

Moore, George T., St. Louis, Mo.
Director Missouri Botanical Garden.
Botany.

Noyes, William Albert, Urbana, Ill., Fellow...................... 1893
Director of Chemical Laboratory, University of Illinois.
Chemistry.

Reagan, A. B.
Superintendent Deer Creek Indian School, Ibopah, Utah.
Geology, Paleontology, Ethnology.

Smith, Alexander, care Columbia University, New York, N. Y., Fellow 1893
Head of Department of Chemistry, Columbia University.
Chemistry.

Springer, Alfred, 312 East 2d St., Cincinnati, Ohio.
Chemist.
Chemistry.

Swain, Joseph, Swarthmore, Pa., Fellow........................1898
President of Swarthmore College.
Science of Administration.

Waldo, Clarence A., 401 West 18th St., New York City............ 1893
Mathematics, Mechanics, Geology and Mineralogy.

Wiley, Harvey W., Cosmos Club, Washington, D. C., Fellow....... 1895
Professor of Agricultural Chemistry, George Washington University.
Bioloqlical and Agricultural Chemistry.

Zeleny, Chas., 1003 W. Illinois St., Urbana, Ill.
Professor of Experimental Zoology.
Zoology.

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Baker, William Franklin, Indianapolis, care Eli Lilly Co.
Medicine.

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Beals, Colonzo C., Russiaville.
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Mathematics.

Bliss, G. S., Fort Wayne.
Medicine, State School for Feeble Minded.

Blose, Joseph, Spiceland.
Physics.

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Canis, Edward N., R. F. D. No. 17, Clermont.
Officeman with William B. Burford.
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Chemistry, Experiment Station.

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Physics and Chemistry.

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Psychology.

Cromwell, Hobart, Salem, Ind.
Zoology.

Crowell, Melvin E., Camborn, B. C.
Chemistry and Physics.

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Mathematics, Valparaiso University.

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Conchology.

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Physiography, Geography, Climatology.

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Deppe, C. A., Franklin.
Franklin College.

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Entomology, Eugenics, Parasitology, Plant Pathology.

Doan, Martha, Richmond.
Professor of Chemistry, Earlham.

Dolan, Jos. P., Syracuse.

Dostal, Bernard F., Philadelphia, Pa.
Laboratory of Physics, University of Pennsylvania.

Douglas, Benjamin W., Trevlac.
Fruit Culture.

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Palæontology and Ecology.

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Chemistry, Purdue University.

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Genetics, with State Board of Charities.

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Merchant.
Botany, Ornithology.

Felver, William P., 325½ Market St., Logansport.
Railroad Clerk.
Geology, Chemistry.

Fisher, Homer Glenn, Johns Hopkins Medical School, Baltimore, Md.
Student in Medicine.

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Student, Zoology, Purdue University.

Fisher, Martin L., Lafayette.
Professor of Crop Production, Purdue University.
Agriculture, Soils, Crops, Birds, Botany.

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Instructor in Chemistry, Purdue University.

Froemming, Albert H., Station D., R. R. 3, Milwaukee, Wis.
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Anatomy.

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Chemistry, Nutrition.

Funk, Austin, 404 Spring St., Jeffersonville.
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    Diseases of Eye, Ear, Nose and Throat.

Galloway, Jesse James, Geology Department, Columbia University.
    New York City.
    Geology, Paleontology.

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    Professor of Surgery.
    Anatomy.

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    Teacher of Botany.
    Botany and Zoology.

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    Professor of Pharmacy, Purdue University.

Gillum, Robert G., Terre Haute.
    State Normal School.

Glenn, Earl R., New York City.
    The Lincoln School of Teachers College, Columbia University.
    Physics.

Goldsmith, William Morton, Gunnison, Colo.
    Colorado State Normal School.
    Biology.

Gottlieb, Frederic W., Morristown.

Care Museum of Natural History, Assistant Curator, Moores Hill
    College.
    Archaeology, Ethnology.

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    Physician.

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    Science of Law.

Hanna, U. S., Bloomington.
    Professor of Mathematics.

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Happ, William, South Bend.
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Medicine, Surgery, X-Ray, Electro-Therapeutics.

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Geology.

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Huber, Leonard L., Hanover.
Zoology.

Hurd, Cloyd C., Crawfordsville.
Zoology.

Huchinson, Emory, Norman Station, Ind.
Zoology.

Hutton, Joseph Gladden, Brookings, South Dakota.
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Agronomy, Geology.

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Cornell Medical School.

Iddings, Arthur, Hanover.
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Imel, Herbert, South Bend.
Zoology.

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Botany, Agricultural Experiment Station.

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Mathematics, Purdue University.

Jordan, Charles Bernard, West Lafayette.
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Nature Study.

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Geology.

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Physical Chemistry.

Ludwig, C. A., R. R. 1, Brookville.
Botany.

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Experimental Engineering in Steam and Gas.

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Plant Pathology and Mycology.

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Physical Geography and Geology.

Malott, Clyde A., 316 East 2nd St., Bloomington.
Geology.

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Martin, Dr. H. H., LaPorte, Ind.
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Entomology, Purdue University and Experiment Station.

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Mathematics.

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U. S. Department of Agriculture, Bureau of Entomology.
Insect Physiology.

McKinley, Lester, Bloomington.
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Botanist for Eli Lilly Co.
Botany, Plant Breeding.

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Physics.

Montgomery, Charles E., 360 Augusta Avenue, DeKalb, Ill.
Assistant Professor of Biology, Normal School.

Montgomery, Ethel, South Bend.
Physics.

Montgomery, Dr. H. T., 244 Jefferson Bldg., South Bend.
Geology.

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Graduate Student and Assistant in Psychology.

Morrison, Harold, Federal Horticultural Board, Washington, D. C.
Entomology.

Morrison, Louis, 80 S. West St., Richmond (France).

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Mechanical Engineering.

Murray, Thos. J., Blacksbury, Va.
Bacteriology, Virginia Polytechnic Institute.

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Chemistry, Purdue University.

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Chemistry and Bacteriology, Agricultural Experiment Station.

Oberholzer, H. C., National Museum, Washington, D. C.
Biology.

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Orahood, Harold, Kingman.
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Plant Pathology.

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Botany, Plant Breeding, Plant Pathology, Bio-Chemistry.

Pickett, Fermen L., Pullman College Station, Washington.
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Botany, Agricultural Experiment Station.

Powell, Horace, Hazleton.
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Ramsey, Glenn Blaine, Orono, Me.
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Rice, Thurman Brooks, Winona Lake.
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With Eli Lilly & Co.
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Tucker, Forest Glen, Columbus, Ohio.
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Warren, Don Cameron, Bloomington.
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Weatherwax, Paul, Bloomington.
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Wilson, Guy West, Carmel.
    Mycology and Plant Pathology.
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    Professor of Pathology, Indiana University School of Medicine.
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    Head of Department of Mechanical Engineering, Purdue University.
Young, Simon J., Valparaiso.
    Physician, Lt. Col., M. C., N. A.
Zehring, William Arthur, 303 Russell St., West Lafayette.
    Assistant Professor of Mathematics, Purdue University.
    Mathematics.

Fellows	65
Members, Active	231
Members and Fellows, Non-resident	38
Total	334

Minutes of the Spring Meeting,

INDIANA ACADEMY OF SCIENCE,

May 17 and 18, 1917.

The spring meeting of the Indiana Academy of Science was held Thursday and Friday, May 17 and 18, 1917, at Purdue University, in connection with the dedication of the new biology building, Stanley Coulter Hall of Biology.

Thursday Afternoon—2:00 o'Clock, May 17th.

Reception of the building for the University and address by President W. E. Stone.

Brief Addresses by—

President W. J. Moenkhaus, representing the Indiana Academy of Science;

John S. Wright, Esq., representing the Alumni;

Dr. H. C. Cowles, Chicago University, on Botany;

Dr. C. H. Eigenmann, Indiana University, on Zoology.

A complimentary supper was served to members of the Academy and invited guests, at 6:00 o'clock, in Stanley Coulter Hall of Biology.

Thursday Evening—8:00 o'Clock.

Address—

"The Modern Biological Laboratory and Public Health," Professor W. T. Sedgwick, Massachusetts Institute of Technology.

Friday, May 18th, Field Trip.

The members of the Academy and guests assembled at Stanley Coulter Hall of Biology at 8:00 o'clock a. m. The loaded automobiles started out at half-minute intervals for the trip. It was planned especially to view Pine Creek valley and vicinity. The automobiles proceeded along the lowland of the Wabash River to Granville Bridge, thence to Greenhill and across the upland to Rainsville, thence along Pine Creek to the "Narrows" of Mud Creek, one of its tributaries, where luncheon

was served. From the "Narrows" the party proceeded to Mudlavia, thence to Attica, and then to Lafayette, following the Wabash River.

The trip afforded an opportunity to visit the Native White Pine regions of northwestern Indiana. At the high bridge east of the Warren County Farm detached rocks and high cliffs were of extreme interest to geologists and students of physiography. This is the northern extension of the geologic features which occur at Turkey Run.

Many of the party walked from the Warren County Farm to the "Narrows."

Business Session.

The meeting was called to order, after luncheon, on a hill-side near Mud Creek west of Attica, by President W. J. Moenkhaus. Sixty members attended the meeting, and about thirty additional persons participated in the field trip and luncheon, as guests of the Academy.

In the absence of members of the Membership Committee the Secretary submitted the names of persons proposed for membership. On motion, duly passed, they were elected to membership in the Academy. The new members are:

Michael James Blew, 215 Indiana Avenue, Bloomington.
Hobart Cromwell, Terre Haute.
Richard G. Dukes, West 7th Street, West Lafayette.
Loyal W. Fisher, 16 Salisbury Street, West Lafayette.
Armenis F. Knotts, 800 Jackson Street, Gary.
Edwin J. Kohl, 105 Fowler Avenue, West Lafayette.
H. H. Martin, M. D., Laporte.
C. O. Lee, Russell Street, West Lafayette.
Morris E. McCarty, 224 Fowler Avenue, West Lafayette.
Louis A. Morrison, 80 S. West 7th Street, West Lafayette.
George W. Munro, 202 Waldron Street, West Lafayette.
Robert E. Snodgrass, 1819 N. New Jersey Street, Indianapolis.
Carl G. Watson, 120 Thornell Street, West Lafayette.
Charles G. Woodbury, 615 University Street, West Lafayette.

Amos W. Butler reported the continuance of the annual appropriation of $1,200 by the State Legislature for the purpose of printing the Proceedings.

R. W. McBride discussed the matter of urging the Printing Board to speed up its work on the 1916 Proceedings.

On motion, duly passed, a committee consisting of the President, Secretary, and Judge McBride, is authorized to visit the Governor in an effort to hasten the work of publication of the Proceedings.

On motion, Editor Lee F. Bennett is empowered to use his discretion in making up the 1916 Proceedings, by elimination of some of the papers, or to reduce their length if they would otherwise add too much to the size and cost of the volume.

It is further urged that an effort be made to embody in the 1916 Proceedings a paper by Professor Hadley of Monrovia, on "David Worth Dennis—An Appreciation."

On motion, the Committee on Distribution of Proceedings is to fix prices at which back numbers of the publication may be procured, and to report at the Fall Meeting.

The following resolutions by Frank B. Wynn, on the State Parks, and by Amos W. Butler, on Appreciations, were received, and passed by the Academy:

Resolved, That the Indiana Academy of Science most heartily approves the attitude of the Governor of the State in promoting the movements for State Parks; first, because it will insure the preservation of native forests, and beautiful natural places which are now rapidly being destroyed and can not be replaced.

Secondly, We urge their preservation as health and recreation preserves for all the people for all time to come.

In the midst of this, the largest Spring Meeting of the Indiana Academy of Science, we express our appreciation of the fine hospitality of Purdue University, which has made this occasion a remarkably successful one. To President Stone, Dean Coulter and all of his associates, to the ladies for the welcome luncheon, and to the ladies of the Household Economics Department, for the splendid supper, our grateful acknowledgments are made, and to all who have contributed to this meeting our sincere thanks are given.

We also wish to make formal recognition of the notable advance made by Purdue University in the erection of the new biology building, so well planned for its purpose and so well built, to express our appre-

ciation of the wisdom shown in naming it for the Head of the Department of Biology, Dr. Stanley Coulter, a distinguished and beloved member of this body.

Professor McBeth of the State Normal School, was then called upon to speak briefly of the geological formation of the region covered in the field trip, after which the meeting adjourned.

W. J. MOENKHAUS, President.
HOWARD E. ENDERS, Secretary.

EVENING—FRIDAY, MAY 18TH.

Reception to members of the Academy in Stanley Coulter Hall of Biology, by the University Club.

SATURDAY—MAY 19, 1917.

A number of the members of the Academy joined in a visit to the Tippecanoe Battlefield and the State Soldiers' Home.

Minutes of the Fall Meeting,

INDIANA ACADEMY OF SCIENCE,

INDIANA UNIVERSITY, BLOOMINGTON, INDIANA,

December 6, 1917.

The Executive Committee of the Indiana Academy of Science met in the Faculty Room of Maxwell Hall, and was called to order by the President, W. J. Moenkhaus, of Bloomington. The following members were present: F. M. Andrews, Lee F. Bennett, Wm. M. Blanchard, H. L. Bruner, W. A. Cogshall, C. C. Deam, Howard E. Enders, Edwin Morrison, D. M. Mottier, Will Scott, Charles Stoltz, and John S. Wright.

The minutes of the Executive Committee of 1916 were read and approved.

The reports of the standing committees were then taken up.

Program Committee—F. M. Andrews, Chairman, reported the work completed as indicated by the printed program of fifty-one titles. On motion, the following title, which arrived too late for entry, was added to the program: "Disposition and Intelligence of the Chimpanzee", by W. Henry Sheak, of Philadelphia, Pa.

Committee on Distribution of Proceedings—Howard E. Enders, chairman, reported that the 1915 Proceedings had been sent out since the last meeting, through the co-operation of the State Librarian, and that the 1916 issue, now in page-proof, will be mailed as early as possible.

Committee on Restriction of Weeds and Diseases—D. M. Mottier, member, reported informally upon the possible value of the work of such committee, but that in view of the fact that the State Board of Health and other agencies in the State are engaged in such work, it would seem to be unnecessary to continue this committee.

On motion, duly passed, the committee is discharged, and this committee hereafter is to be discontinued.

Committee on Relations of the Academy to the State—John S. Wright reported for the committee that the customary twelve hundred ($1,200) dollar appropriation has been made available for the printing of the Proceedings.

Committee on Publication of Proceedings—Lee F. Bennett, chairman and Editor, reported on the incidents in delay of Proceedings. Half of the page-proofs are now in hand, and others will be received soon.

On motion, the Editor of Proceedings is to be allowed the sum of fifty ($50) dollars for expense of clerical hire for the 1916 issue. It is the sense of the Executive Committee that this sum be continued from year to year.

Advisory Council—John S. Wright and W. A. Cogshall reported for the committee that they had conferred with the Governor of the State relative to the matter of placing properly qualified men in the scientific offices of the State, and that he had given assurance of such co-operation.

Committee on Academy Foundation—The report of this special committee, appointed a year ago, was read by the chairman, H. L. Bruner.

On motion, the report is hereby received and is to be submitted to the members of the Academy for consideration at the business session to-morrow.

Wm. M. Blanchard, Treasurer, reported as follows:

Balance in Treasury December 2, 1916	$378 49
Dues collected during the year	344 00
Total	$722 49
Expenditures	197 91
Balance in treasury, December 1, 1917	$524 58

The report was received and, in the absence of P. N. Evans, was referred to W. A. Cogshall for audit.

There were no reports from the committees on State Library and Biological Survey.

H. E. Enders reported relative to the matter of setting a price for back numbers of the Proceedings, as directed at the Lafayette Spring Meeting. The committee advises that, inasmuch as the State pays for the publication of the Proceedings, we have no authority to offer for sale or receive money for copies of the Proceedings. It is advised that the practice be followed of sending copies to interested workers upon application, and prepayment of the carriage charges.

On motion, a committee of three was appointed to prepare amend-

ments to the Constitution and By-Laws to define the duties of Editor of Proceedings, and to recognize the position as an officer of the Executive Committee.

John S. Wright, Lee F. Bennett and W. A. Cogshall were appointed to serve as members of this committee.

On motion it is recommended that the 1918 Program Committee determine the feasibility of inviting the members of the Illinois Academy of Science to hold their Spring Meeting as a joint meeting with the Indiana Academy of Science, at some time and place to be determined by the committees of these Academies.

Adjourned.

W. J. MOENKHAUS, President.
HOWARD E. ENDERS, Secretary.

GENERAL SESSION.

SCIENCE HALL, 10:15 A. M., DEC. 7, 1917.

The meeting called to order by President W. J. Moenkhaus.

In accordance with the arrangements of the Program Committee the Academy proceeded at once with the reading of the general papers numbered 1 to 5, after which the body went into businss session.

Business:

The minutes of the Executive Committee were read and approved.

The report of the committee appointed to investigate the advisability of establishing a research endowment fund to be known as the Academy Foundation, was received and was considered at some length, after which the following resolution was passed:

Resolved, That the Academy expresses sympathy in the movement and refers the matter back to the Committee on Academy Foundation for further amplification, and for private publication and circulation among members of the Academy during the ensuing year, with a view to its consideration in 1918.

Auditor W. A. Cogshall reported upon the correctness of the report of the Treasurer.

Report of progress in the Biological Survey was made by chairman, C. C. Deam.

The following named persons were proposed for membership, and were elected:

Harold R. Brown, Earlham College, Richmond, Indiana.
Anna Mary Collins, Irvington, Indianapolis, Indiana.
Martha L. Denny, Bloomington.
Charles S. Driver, Bloomington.
Walter N. Hess, Greencastle.
Richard M. Holman, Crawfordsville.
Moses A. Jacobson, West Lafayette.
Jacob Papish, Bloomington.
Louis Roark, Bloomington.
Lewis A. Taylor, Earlham College, Richmond.
Eben Henry Toole, West Lafayette.

The following named members were elected Fellows:

J. A. Badertscher, Professor of Anatomy, Indiana University.

Charles A. Behrens, Professor of Bacteriology, Purdue University.

Edward W. Koch, Department of Research, Eli Lilly Co., Indianapolis.

William M. Logan, Associate Professor of Geology, Indiana University.

Barnard Schockel, Professor of Geography, State Normal School.

The report of the Nominating Committee was as follows:

President—E. B. Williamson, Bluffton.
Vice-President—Dr. Charles Stoltz, South Bend.
Secretary—Howard E. Enders, West Lafayette.
Assistant Secretary—P. A. Tetrault, West Lafayette.
Treasurer—Wm. M. Blanchard, Greencastle.
Editor—Lee F. Bennett, Valparaiso.
Press Secretary—Frank B. Wade, Indianapolis.

The Committee on Amendments moved the following amendments to the Constitution and By-Laws, for final action to-morrow:

Amendment to Constitution, Article III, Section 1, second sentence, by insertion of the word "Editor" after the words "Press Secretary."

The article and section so amended will read:

"SECTION 1. The officers of this Academy shall be chosen by ballot, at the annual meeting, and shall hold office one year. They shall consist of a President, Vice-President, Secretary, Assistant Secretary, Press Secretary, Editor, and Treasurer, who shall perform the duties usually pertaining to their respective offices and in addition, with ex-presidents of the Academy, shall constitute an Executive Committee. The President shall, at each annual meeting, appoint two members to be a committee, which shall prepare the programs and have charge of the arrangements for all meetings for one year."

Amendment to the By-Laws:

"BY-LAW 8. An Editor shall be elected from year to year. His duties shall be to edit the annual Proceedings. No allowance shall be made to the Editor for clerical assistance on account of any one edition of the Proceedings in excess of fifty ($50) dollars except by special action of the Executive Committee."

AFTERNOON SESSION—1:30 P. M.

Papers numbered 6, 7, and 8 were read in general session after which the Academy adjourned to sectional meetings. President Moenkhaus served as chairman of the section on Bacteriology, Botany and Zoology; and Edwin Morrison presided over the section on Astronomy, Chemistry, Geology and Physics.

EVENING SESSIONS.

The address of the retiring President, Professor W. J. Moenkhaus, was delivered at the informal dinner, at the Cafeteria, at 7:00 p. m.

At 8:30 Professor Charles T. Knipp, of the University of Illinois, addressed the members of the Academy and guests on the subject: "Electric Discharge in Vacuum Tubes—The Electron." The extensive equipment and the facilities of the Department of Physics made it possible to illustrate the whole of the lecture in a striking manner.

A smoker and informal entertainment was given by the Sigma Xi Scientific Fraternity at the Faculty Club rooms immediately after Professor Knipp's address.

SATURDAY, DECEMBER 8, 1917.

Business:

The meeting was called to order at 8:45 by President Moenkhaus.

The amendments to the Constitution and By-Laws were called for second reading, and were passed on motion.

The following named Fellows were elected Non-Resident Fellows:

Charles Zeleny, Professor of Experimental Zoology, University of Illinois, Urbana, Illinois.

Severance Burrage, Resident of Massachusetts, now with a medical commission in Serbia.

The matter of the Spring Meeting was discussed. In view of the fact that members of the Illinois Academy of Science have suggested that a joint meeting be held with their Academy it is advised that the 1918 Program Committee take up the matter and determine whether this is feasible; if so to complete the plans, otherwise to determine a place and time for an independent meeting.

The Academy adopted the following resolution presented by Wm. M. Blanchard:

Resolved: That we extend to Indiana University, and particularly to the members of the Academy who are connected with the University, as well as to our special visitor, Professor Charles T. Knipp, a vote of thanks for the entertainment and courtesy manifested at this December meeting of the Academy.

The Academy then went into general session for the reading such papers as remain from the several sections.

Adjourned.

W. J. MOENKHAUS, President.
HOWARD E. ENDERS, Secretary.

Program of the Thirty-third Annual Meeting,

OF THE

INDIANA ACADEMY OF SCIENCE,

HELD AT

INDIANA UNIVERSITY, BLOOMINGTON, IND.,
Friday and Saturday, December 7 and 8, 1917.

OFFICERS.

W. J. MOENKHAUS, President
EDWIN MORRISON, Vice-President
HOWARD E. ENDERS, Secretary
WILLIAM M. BLANCHARD, Treasurer
P. A. TETRAULT, Assistant Secretary
FRANK B. WADE, Press Secretary
LEE F. BENNETT, Editor

PROGRAM COMMITTEE.

F. M. ANDREWS H. L. BRUNER
STANLEY COULTER

GENERAL PROGRAM

THURSDAY.

Meeting of the Executive Committee in the Faculty Club Rooms .... 8:00 p.m.

FRIDAY.

Business Session .... 11:30 a.m.
General Session .... 10:00 a.m.
Sectional Meetings .... 1:30 p.m.
Informal Dinner at the Cafeteria .... 7:00 p.m.
The address of the retiring President, Professor William J. Moenkhaus, of Indiana University, will be delivered at this time.
Address by Professor Charles T. Knipp .... 8:30 p.m.

Subject: Electric Discharge in Vacuum Tubes—"The Electron," Science Hall, Room 38.

A smoker will be given by the Sigma Xi Scientific Fraternity at the Faculty Club Rooms immediately after Professor Knipp's address.

SATURDAY.

Business Session .... 8:00 a.m.

GENERAL SESSION.

FRIDAY, 10:00 A.M.

1. Transplantation of Testes into Ovariectomized Female Guinea Pigs, 5 min............................By Mathew Winters
   Presented by Dr. B. D. Myers, Indiana University.
2. The Physiography of Indianapolis, 15 min. (by title).Chas. R. Dryer
3. The Pygidiidae, 30 min.......C. H. Eigenmann, Indiana University
4. Some criteria of Skeletal Homologies, 15 min.................. ....J. S. Kingsley, University of Illinois
5. A Fish Epidemic in Huffman's Lake, 10 min.................. ....Will Scott, Indiana University
6. Germinal Changes Affecting Facet Number in the Bar-eyed Race of Drosophila, 10 min............................. ....Charles Zeleny, University of Illinois
7. The Dwarfing Effect of Attacks of Mites of the Genus Eriophydae upon Norway Maples, 10 min....................... ....Howard E. Enders, Purdue University
8. Where the Feeble-minded are Self-supporting, 12 min......... ....Hazel I. Hansford, Indiana University

SECTIONAL MEETINGS.

FRIDAY 1:30 P.M. AND SATURDAY 8:30 A.M.

Astronomy.

1. A New Form of Telescope Mounting, 10 min.................. ....W. A. Cogshall, Indiana University

Bacteriology.

2. Bacterial Action on Proteins in presence of Carbohydrates, 10 min. H. M. Weeter, Purdue Univ.; George Spitzer, Purdue Univ.

3. Hydrolysis of Proteins and Methods of Separating the Cleavage Products, 10 min.............Geo. Spitzer, Purdue University

Botany.

4. Plastids, 10 min. (by title)......D. M. Mottier, Indiana University
5. Species of Martyniaceae, 5 min..Flora Anderson, Indiana University
6. Variation and Varieties of Zea Mays, 10 min......................................Paul Weatherwax, Indiana University
7. Improved Technique for the Control of Pollination in Corn, 10 min....................Paul Weatherwax, Indiana University
8. Dormant Period of Timothy Seed after Harvesting, 10 min.................................M. L. Fisher, Purdue University
9. The Plant Succession on Niagara and Hudson River Limestone, near Richmond, Ind., 5 min. (by title)...M. S. Markle, Earlham College
10. Notes on Microscopic Technique, 5 min. (by title)...M. S. Markle, Earlham College
11. The Ustilaginales of Indiana, 10 min..H. S. Jackson, Purdue University
12. The Uredinales of Indiana, 10 min..................H. S. Jackson
13. A Suspected Case of Live-Stock Poisoning by Wild Onion (Allium Canadense), 10 min. (by title)..F. J. Pipal, Purdue University
14. Additions to the list of Plant Diseases of Economic Importance in Indiana, 10 min. (by title)..Geo. A. Osner, Purdue University
15. Reaction of Culture Media, 10 min. (by title)...H. A. Noyes, Purdue University
16. Studies on Pollen, 5 min........F. M. Andrews, Indiana University
17. Stoppage of a Sewer Pipe by Roots of Acer Saccharum, 5 min...........................F. M. Andrews, Indiana University
18. Anthocyanin of Beta Vulgaris, 5 min...F. M. Andrews, Indiana University
19. Improved Forms of Maximow's Automatic Pipette, 5 min...............................F. M. Andrews, Indiana University
20. The Effect of Centrifugal Force on Plants, 5 min...................................F. M. Andrews, Indiana University

21. The Effect of Aeration on the Roots of Zea Mays, 5 min........ ....Colonzo C. Beals, Indiana University
22. Resistance of Mucor Zygotes, 20 min........................ ....Mildred Nothnagel, Indiana University

Chemistry.

23. The Absorption of Iron by Platinum Crucibles in Clay Fusions, 5 min.................................W. M. Blanchard, DePauw University; Roscoe Theibert, DePauw University
24. The Injurious Effect of Borax in Corn Fertilizers, 10 min. (by title).....................S. D. Conner, Purdue University
25. Chemical Estimations of Fertility in Fulton County (Ind.) Soils, 15 min.........R. H. Carr and G. A. Gast, Purdue University
26. By-products of the Preparation of Ether, 10 min. (by title)... ....P. N. Evans and G. K. Foresman, Purdue University
27. Quantitative Precipitation of Manganese as the Sulphide, 15 min...........................James Brown, Butler College
28. The Influence of Methyl Iodide Vapor and Tobacco Smoke on the Growth of Certain Bacteria and Fungi (by title)..C. A. Ludwig

Geology.

29. Brief Notes on the New Castle Tornado, 10 min............... ....Colonzo C. Beals, Indiana University
30. "The Mt. Carmel Fault," 5 min....W. N. Logan, Indiana University
31. "Some Criteria of Dip," 5 min.....W. N. Logan, Indiana University
32. "Possible Utilization of Indiana Kaolin," 5 min............... ....W. N. Logan, Indiana University
33. "The Physiographic Divisions of the United States as made by the Fenneman Committee," 5 min....................... ....F. J. Breeze, Indiana University
34. "Glacial Boulders in Brown and Monroe Counties, South of the Limit of Glaciation, 15 min...................... ....F. J. Breeze, Indiana University
35. "Field Methods in the Mid-Continental Oil Field," 15 min...... ....Louis Roark, Indiana University

Physics.

36. Energy Loss in Commercial Hammers, 15 min................ ....Edwin Morrison and Robert L. Pelry, Earlham College
37. Some Experiments on Resonance of Tubes and Horns, 5 min... ....Arthur L. Foley, Indiana University
38. Two New Photographic Methods of Measuring the Speed of Sound Waves, 10 min......Arthur L. Foley, Indiana University
39. Conditions Affecting the Speed of Sound Waves, 10 min........ ....Arthur L. Foley, Indiana University
40. The Conduction of Heat and Electricity Thru Selenium, 10 min. ....Arthur L. Foley, Indiana University
41. Some Observations on Fluorescence, 5 min.................... ....Arthur L. Foley, Indiana University
42. Further Notes on the Identity of X-Rays and Light, 10 min.... ....Mason E. Hufford, Indiana University
43. An improved Form of High Vacuum High Speed Mercury Vapor Air Pump, 10 min......Charles T. Knipp, University of Illinois

43a. A Possible Standard of Sound. Chas. T. Knipp, University of Illinois

44. Visible Color Effects in a Positive Ray Tube Containing Helium, 10 min..................Chas. T. Knipp, University of Illinois

Zoology.

45. The Effect of Artificial Selection upon Bristle Number in the Fruit Fly and the Interpretation of the Results, 15 min... ....F. Payne, Indiana University
46. The Unionidæ of Lake Maxinkuckee, 20 min. (by title)....... ....Barton Warren Evermann, California Academy of Science; Howard Walton Clark, U. S. Biological Station, Fairport, Iowa
47. A Day with the Birds of a Hoosier Swamp, 10 min. (by title)... .....Barton Warren Evermann, California Academy of Science
48. Further Experiments with the New Mutant, Scarlet in the Drosophila Repleta, 10 min......................H. W. Cromwell
49. A Seasonal Study of the Stickleback Kidney, Cayuga Jordan, 15 min......................Walter N. Hess, DePauw University
50. On the Locus of the Gene for the Mutant, Curved (by title).. ....Roscoe R. Hyde, Indiana State Normal

51. The Erdmann New Culture Medium for Protozoa, 20 min..... ....By C. A. Behrens, Purdue University; H. C. Travelbee, Purdue University
52. Disposition and Intelligence of the Chimpanzee............. ....W. Henry Sheak, Philadelphia, Pa.
53. The Uredinales of Delaware......H. S. Jackson, Purdue University
54. The Trees of White County, Indiana....................... ....Louis L. Heimlich, Purdue University

THE PHYSIOGRAPHY OF INDIANAPOLIS.

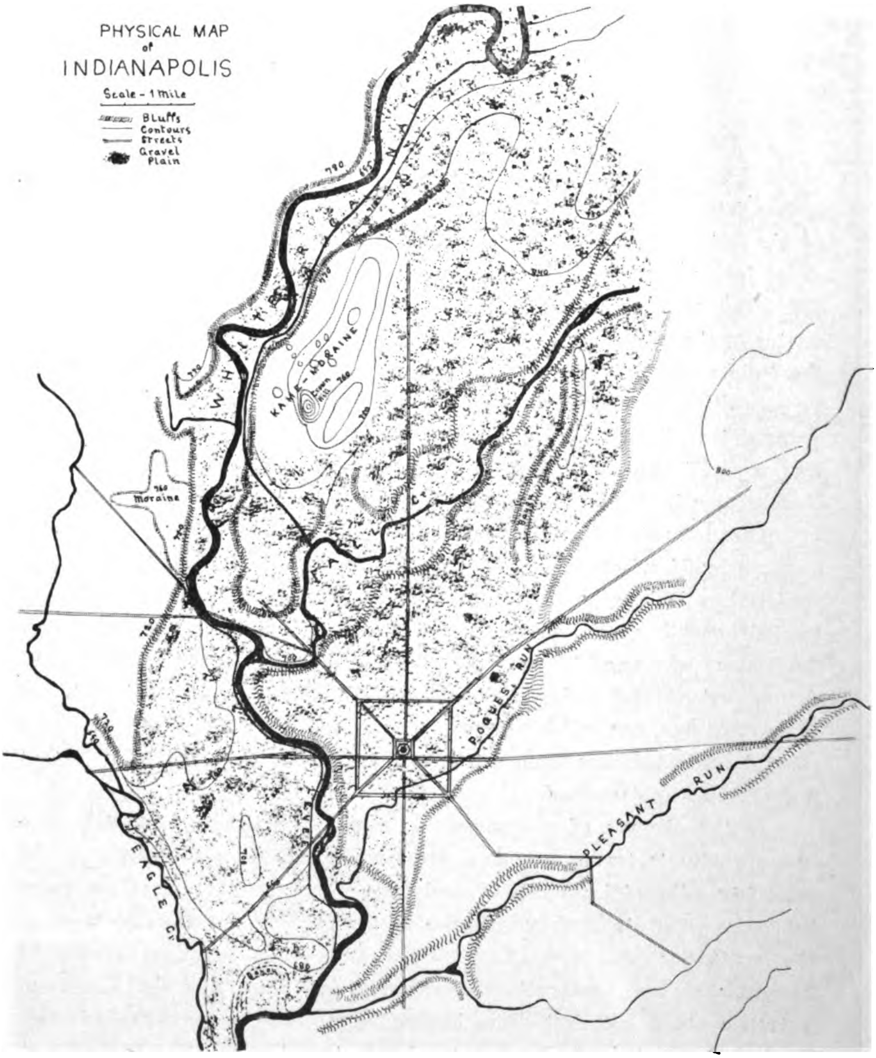
CHARLES R. DRYER, Indiana State Normal School.

In 1820, the Indiana Commissioners fixed upon a point in the uninhabited wilderness, "on White river at the head of navigation" and within ten miles of the geographical center of the State for the location of the future capital. Congress had granted to the State four square miles for use as a seat of government, and in 1821 a plat of one square mile was surveyed which now comprises the official and commercial center of the city. The area was situated near the eastern border of the flood plain of White River and a few feet above it, but was traversed by Pogues Run, a small tributary. Fall Creek, a much larger stream, entered the river from the northeast just above the city and Pleasant Run a short distance below. On the opposite side of the river, Eagle Creek came in from the west.

The present metropolitan district would be enclosed by a parallelogram 8 by 10 miles, of which about 35 square miles are built up. The underlying bed rocks are Devonian limestones and shales too deeply buried beneath glacial material to influence topography. The Illinoian drift sheet of compact blue clay, varies from 20 to 80 feet in thickness. A few feet of sand and gravel separate it from the usual bouldery till of Wisconsin age, the whole forming a mantle 70 to 170 feet thick. This glacial subtratum has been eroded and replaced by gravel to an extent presently to be described.

In the absence of a topographic map relief can be described only in approximate terms. Central Marion County is crossed from northwest to southeast by a belt of undulating drift in part morainic about ten miles wide, its surface lying about 800 feet A. T. It is bordered on the south by massive gravel ridges and other morainic features.* Through this belt nearly at right angles, White River and Fall Creek cut a trench about 200 feet deep, having its bottom on or near bed rock. During the period of glacial retreat this trench was filled half full of gravelly outwash. A readvance of the ice margin, accompanied by the

* Leverett, Frank. U. S. Geol. Surv. Monograph LIII, p. 96.


PHYSICAL MAP
of
INDIANAPOLIS
Scale - 1 Mile
Bluffs
Contours
Streets
Gravel
Plain
WHITE RIVER
KAME-MORAINE
Moraine
FALL CR.
POGUES RUN
PLEASANT RUN
EAGLE CR.

escape of subglacial streams, deposited near the western border of the outwash plain a belt of sand and gravel hills three miles long and rising in the sharp knob of Crown Hill 90 feet above the plain and 150 feet above the river. White River passes through this kame-moraine in a gorge three miles long and half a mile wide, bordered by steep bluffs 40 to 80 feet high. The gravel plain about three miles wide is bounded on the east by a gentle rise or bluff 15 to 30 feet high, which parallels Fall Creek and touches the river at the mouth of Pleasant Run, below which the plain lies on the west side of the river. Its surface slopes from about 740 feet A. T. in the north to 680 feet in the south, or about six feet to the mile and is cut by the high water channels of the river, Fall Creek and Eagle Creek, into a series of low but well defined terraces. The city occupies the gravel plain, the kame-moraine and the gorge, bluffs and flood plain of White River, and extends on the east and south several miles beyond the bluff over the more elevated undulating drift.

The physical features have influenced the development of the city, favorably and unfavorably, in various ways. White River is a commercial obstruction, too small for navigation, inadequate for sewerage and entailing large expense for bridges and levees. It pays some compensation in water supply and picturesque sites for parks and residences. The gravel plain makes grading and excavation inexpensive and surface drainage rapid; but this credit account is balanced by a debit of 25,000 wells subject to serious contamination. Pogues Run has cost untold sums in damage to health and property by floods and the expense of conversion into a covered sewer, but furnishes a route by which several railroad lines enter the city. The low bluffs and terraces of Fall Creek and Pleasant Run are utilized for boulevards and parkways. The Crown Hill kame-moraine, the most striking and attractive natural feature of the area, is admirably suited for the abode of the living or the dead and forms the beautiful site of Crown Hill Cemetery. The smooth surface of the surrounding drift plain is a prime factor in the accessibility which makes Indianapolis the largest center of exclusively land transportation in the United States.

THE PYGIDIIDAE.

CARL H. EIGENMANN, Indiana University.

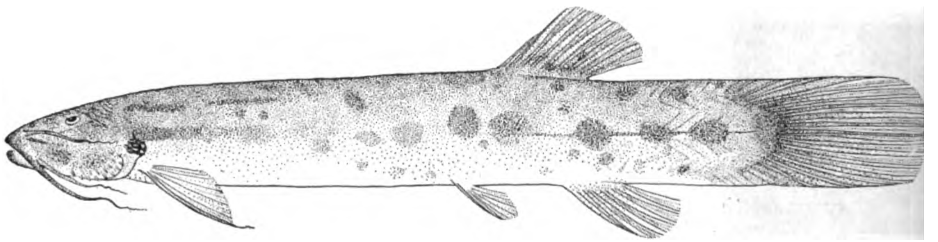
There is a widespread belief in parts of South America that a fish called Candirú has the vicious habit of entering the urethra of bathers. Its opercle and interopercle bear retrorse spines that are erectile. The fish, therefore, cannot be withdrawn. An operation, if not amputation, is necessary to get rid of the pest, and if it has penetrated to the bladder it causes death. This story has been told many different travelers. Some have rejected it as beyond belief, others have added to the marvelous, while still others have tried to identify the fish. The result of the latter attempt has been ludicrous at times, inasmuch as the identification would require the reverse of the well recognized principle of logic that the greater cannot enter the lesser. Some of the Candirús reach a considerable size, a length of at least a foot and a thickness of at least two inches. We will return to the Candirús.

I have finished a monograph of the family of fishes, the Pygidiidæ, of which the smaller Candirús are members, and I want to give a brief account of the different types of fishes that are included in this family. Other species of the family have well authenticated habits as remarkable as those of the Candirú, and I am figuring all the species I can get.

I find that there are nearly a hundred well defined species of the Pygidiidæ. Many of these are very rare. Forty-four are known from the types only, several have been recorded from but two localities. The types are widely scattered in the museums of North America, South America, and Europe. At one time or another I have examined practically all of the specimens in American museums, and have myself discovered nine of the nineteen genera, and forty-three of the ninety-seven species. Eight or ten of the types are in Vienna, two are in Berlin, twelve in Paris, eleven in London, one in Torino, two probably in Munich, one in Leipzig, two in Copenhagen, one in Berne, three presumably in Santiago, Chile, three in Buenos Aires, three in Rio de Janeiro, two in Cordoba, Argentine, one in the Field Museum, two in the Philadelphia

* Contribution from the Zoölogical Laboratory of Indiana University, No. 163.

Academy of Sciences, eight in the Museum of Comparative Zoölogy, five in Indiana University, one in Princeton University, twenty-four in the Carnegie Museum. The type of one species, the only known specimen of the species, has been lost.



A Pygidium.

The particular type of catfish underlying all of the Pygidiidæ is that of a short eel with a little barbel on the anterior nostril, twin barbels at the angle of the mouth, small teeth in bands in the jaws, bunches of spines on the margin of the preopercle and on the opercle, the first dorsal and pectoral rays not spinous, the dorsal placed behind the middle of the body and not followed by an adipose fin. The principal peculiarities are the twin barbels at the angle of the mouth, the absence of an adipose fin and the development of opercular and interopercular spines—never mind the internal economy. Nobody knows, at least I don't, why there are *twin* barbels at the angle of the mouth, or why there is no adipose fin. It is easy to see that the spines on interopercle and opercle are important. They are an adaptation to the insinuating habit and prevent an exsinuation if the fish objects to coming out.

From this basal idea of the Pygidiidæ have been developed by addition, subtraction and modification several distinct subfamilies, each with subsidiary basal ideas and a larger or smaller number of radiations. There are the Nematogenyinæ with barbels on the chin, remnants really of the more ancient, less specialized cat-fishdom, the Pygidiidæ which are the least specialized of the Pygidiidæ, and meander over all the mountains of South America, both east and west. The most that can be said of them is that there are a lot of them and that when big enough they are good to eat. Then there are the Stegophilinæ with a broad, inferior mouth with innumerable fine teeth in many rows on lips and

jaws, and some, at least, which have exaggerated the insinuating habit to the extent of becoming parasites in the gills of other fishes. Also there are the Vandelliinæ, in which the lower jaws are weak, the rami no longer meeting in the middle, the teeth largely reduced to a few pointed ones in the middle of the upper jaw, with which they make abrasions in the skins of other fishes and of an occasional bather, to drink his blood. To this crowd of disreputables belong the aforementioned Candirú. Finally there are little odds and ends tied into the Tridentinæ, minute creatures, the smallest of which is but 17 mm. long, and the largest but 27 mm. The most that we can say of them is to express the wonder that any of them were caught at all.

The Nematogenyinæ have either lost or never got opercular spines. Nematogenys is large enough to be noticed. It has received the common name "Bagre", and reaches a length of over ten inches at least.

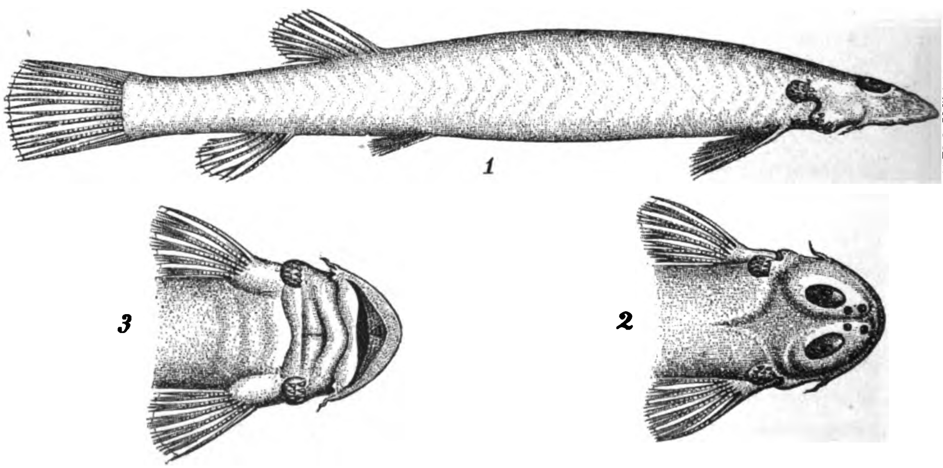
The Pygidiinæ flourish in the mountains from southern Panama to southern Patagonia, and in southeastern Brazil, also in the cataracts of Guiana. A few of them are found in the lowland, but their optimum is only reached in high altitudes, and with Astroblepus, a representative of another catfish type, they reach the highest altitudes attained by fishes in South America.

One of them, *Eremophilus mutisii*, is exceedingly abundant on the Plains of Bogotá, where its name, "El Capitan", expresses the estimation in which this Pygidiid is held. It has the habit of worming its way into the mud and into the banks of streams and lakes. "El Capitan" is speckled like a lake trout, and it is all but confined to the elevated basin in which Bogotá is situated. In the mountain brooks of Colombia many species of the genus Pygidium are found in abundance. I recall one sultry day sitting in a cool, clear, shallow brook near Honda, Colombia, leisurely raking my fingers through the sand and pebbles on the bottom. Minute fishes darted out of the sand and into it and under small rocks. I lined a dipnet with cheese-cloth and went for them, dipping up sand. gravel and all. I soon had a good number, eighty-nine to be exact, of a new species of the genus Pygidium. Mr. E. B. Williamson caught a specimen of another species, which was making its way up the vertical wall of a waterfall. The sixty-three members of the genus Pygidium range from southern Panama to Chile, Guiana and Rio Grande do Sul. Very few species are known from the lowlands, but every mountain

brook has one or more species, never many, and none of them have a wide distribution. They are abundant in Lake Titicaca, and in southern Chile are replaced by the related genus Hatcheria.

A halfway station between the Pygidiinæ with nasal barbel, free gill-membranes and ordinary fish mouth and the small commensals, parasites and disreputables without nasal barbels, with narrow gill-openings and inferior mouth, is found in Pareiodon. In shape and size Pareiodon resembles the Havanas sold to tourists in Habana for a dollar, each one put up in an individual bottle, a corkscrew furnished gratis with each cigar.

Some, at least, of the Stegophilini live in the gill-openings of other fishes. The head in the species of this group is flat below, the mouth a transverse slit, the teeth are minute and numerous, there is no nasal barbel, the gill-opening is greatly restricted, the membrane being united with the broad, flat isthmus. Some of them roam the billows free as cats, others are known to live, occasionally at least, as commensals or parasites in the gill-cavities of other fishes. Reinhardt, a Danish naturalist living for the time at Lagoa Santa, on the Rio das Velhas, a tributary of the San Francisco, was the first one to note this fact and to secure specimens. Reinhardt being told that one of the giant catfishes, *Pseudoplatystoma coruscans*, carried its young in its gills, offered a re-



Stegophilus insidiosus Reinhart.

ward for one with young. Two Platystomas were brought with young, but instead of being the young of the giant catfish, he found that the small fishes were the types of a distinct parasitic or commensal fish, which he called "Stegophilus insidiosus."

It is certain that some members of the Stegophilini live in the open, very probably on sandy beaches; in fact, while but one species is known to live part of its time, at least, in the gills of other fishes there are a number of species that have only been caught in the open. Several years ago Prof. J. D. Anisits, then living in Asuncion, Paraguay, sent me one of these little creatures, which he had caught in a brook near Sapucay. He tried to get others but sorrowfully reported that the locality was gone, the arroyo was dry. While the original member of the Stegophilini came from a medium altitude, the members of the subfamily live largely in the lower levels of the Amazon and La Plata. As it is more probable that specimens living in the open will get into the ichthyologists' bottles than those living in the gill-cavities of larger fishes, it must be left an open question whether the species living in gill-cavities are more numerous than those living in the open, and whether the same species live in the open and in gill-cavities indiscriminately, or whether they only occasionally get into gill-cavities as the result of their inborn, insinuating habit coupled with the blood-sucking specialization.

The three known species of the Tridentinæ, all collected during the Thayer Expedition, in the Amazon Basin near the boundary between Brazil and Peru, were described by my wife and myself in 1898. One of them, *Miuroglanis platycephalus,* captured in 1866 by the combined efforts of James, Thayer and Talisman, in the Jutahy, is or was only seventeen millimeters long. A recent effort to locate the specimen has failed. The same fate seems to have befallen the specimen of *Tridens brevis.* It was but twenty-one millimeters long, and caught in 1866 by Bourget at Tabatinga. The third and last of this group is *Tridens melanops.* In 1866 the future philosopher, William James, caught twenty-seven of them at Iça, the largest only twenty-seven millimeters long. In 1891 the Museum of Comparative Zoölogy sent me one of these, which has just been figured for my monograph. The Tridentinæ are fishes with a greatly depressed head and a large eye placed on the edge of the head; in one, at least, they look down rather than up.

One of the Vandelliini, *Branchioica bertoni,* lives in the gill-cavities

of a large Characin. Several years ago Mr. Bertoni sent me one of these, and it seems that I at once described it with much gusto. Later Mr. Bertoni sent me another lot of minute fishes, and this summer I discovered that two of these were taken from the gills of a Characin. I again described them, of course, as a new genus and species. Still later I found the totally forgotten original specimen and description carefully laid away.

Ribeiro, of the National Museum of Rio de Janeiro, caught another very similar member of a related genus, Paravandellia, among the weeds of the stream near San Louis de Caceres in the upper Paraguay Basin.

With fishes as rare as these and as small as these, the question sometimes arises whether the differences are due to the fact that one worker uses a hand lens and the other a binocular dissecting microscope with an arc spotlight. The results of the two instruments are comparable to the effects produced by an old-fashioned cannon and a modern forty-two-centimeter howitzer.

Two species I have just described with the three previously known, brings the number of Vandellias up to five—maybe. I used a howitzer, and my distinguished predecessors, Pellegrin, Castelnau, Valenciennes and Cuvier used hand lenses. The Vandellias are long, slender, eel-like in shape. There are really two genera in the genus Vandellia, but I don't yet know which one of these Valenciennes had when he named the genus. The other is, for the present, without a legitimate name. When we know which one can legitimately lay claim to the name Vandellia the other one can be baptized as Urinophilus. One of these, possibly two of them if they are different, *Vandellia hasemani* and *Vandellia wieneri*, is or are too large to enter the urethra of man when it is or they are fully grown. On the other hand, *Vandellia cirrhosa*, *sanguinea*, and *plazai* could, as far as their size is concerned, enter the urethra. Do they?

Pellegrin, who has written on this subject, quotes Dr. Jobert who collected fishes in Brazil for the Jardin des Plantes. Jobert tells that a highly reputable physician of Belem, Para, Dr. Castro, told him he had taken a Candirú from the urethra of a negress.

Boulenger (Proc. Zool. Soc. London, 1897, p. 901) says of Vandellia cirrhosa:

"The 'Candirú', as the fish is called, is much dreaded by the natives

of the Jurua district, who, in order to protect themselves, rarely enter the river without covering the genitalia by means of a sheath formed of a cocoanut-shell, with a minute perforation to let out urine, maintained in a sort of bag of palm-fibers suspended from a belt of the same material. The fish is attracted by the urine, and when once it has made its way into the urethra, cannot be pulled out again owing to the spines which arm its opercles. The only means of preventing it from reaching the bladder, where it causes inflammation and ultimately death, is to instantly amputate the penis; and at Tres Unidos, Dr. Bach had actually examined a man and three boys with amputated penis as a result of this dreadful accident. Dr. Bach was therefore satisfied that the account given of this extraordinary habit of the 'Candirú' is perfectly trustworthy. Mr. Boulenger further showed a photograph, taken by Dr. Bach, of two nude Indians wearing the protective purse."

It is to be noted here that, while this evidence is quite circumstantial, it is only circumstantial. Dr. Bach did not himself operate or help to operate or remove the Candirú, and a much simpler operation than amputation would have been sufficient to remove it.

Pellegrin (Bull. Soc. Philom. de Paris, (11), I, 1909, pp. 5-8) further quoting Jobert's account, says that at Para there are two species of Candirús, only one of which penetrates the urethra, the other, the horse Candirú, attaches itself to any part of the body and also attacks horses. Dr. Jobert himself, who went in bathing near Para, was attacked within less than five minutes and found scratches in a group five to six inches long and a centimeter or more wide. He did not secure the creature which attacked him.

In "Die Natur", XIX, p. 180, Müller, in reporting on the travels of Gustav Wallis, says that Wallis noted a fish in the Huallaga called the Candirú, which is as much feared in the water as mosquitoes and ants on land. This Candirú attaches to any portion of the body like a leech and spreads retrorse hooks in the wound so that it is only with considerable pain that it can be removed. It prefers the most secret parts of the body and it was reported to him that the consequent operation sometimes causes death. One specimen of this Candirú was given to Leukart and by him to Lütken, who described it as *Acanthopoma annectens.* It probably belongs to the Stegophilini.

That a fish, or several species of fishes, found in the Amazon Valley

and called Candirú is or are a nuisance is certain. Whether the widely distributed belief that the Candirús are tropic to urine and consequently have a tendency to enter the urethra, or whether the candirú's tendency to burrow leads them accidentally to enter the urethra are all matters that must, for the present, remain in debate. A very interesting subsidiary question is whether, if Candirús are tropic to urine, they do not also enter the urethra of aquatic mammals and large fishes. Further study may demonstrate that some species of Candirús have become parasitic in the bladder of large fishes and aquatic mammals. These are all questions that may legitimately be taken up by the expeditions that will, I hope, result from this article.

An Epidemic Among the Fishes of Huffman's Lake.

Will Scott, Indiana University.

This paper describes an epidemic among the fishes in Huffman's lake during October and November, 1917. The data indicate that these fish died from poison which was derived from a blue-green algæ, either by its metabolism or decay.

Huffman's lake is located in Kosciusko County, Indiana, (Tp. 33 N., R. 5 E.) about one mile northwest of Atwood. It is just west of the Erie-Saginaw interlobate moraine and lies in a slight depression of the ground moraine. It is roughly oval in outline. Its greatest length is about one mile and its greatest width is about one-half mile. Its longitudinal axis extends north and south. Near the middle of the lake there are three small islets situated along the major axis of the lake. Its maximum depth is 9.8 meters.

The land surrounding the lake is low. Much of it near the shore is marshy. To the east, a short distance, the rougher topography of the interlobate moraine begins. The lake is therefore quite exposed to the action of the wind especially to the south, west, and north.

Dead and dying fish were first noted in large numbers after a storm that occurred on October 29th. This storm left a distinct wave deposit some distance above the normal lake level. On November 16 the fish were counted in several sections of this deposit. The average was about one fish per lineal foot of deposit. Six species were collected and identified, bluegill, (Lepomis pallidis Mitchill); large mouthed black bass (Micropterus salmoides Lacépède); calico bass (Pomoxis sparoides Rafinesque); sucker (Catostomus commersonii Lacépède); hickory shad (Dorosoma cepedianum Le Sueur), and yellow perch (Perca flavescens Mitchill).

One hickory shad was identified struggling on its side near the center of the lake. It was able to avoid a dipnet and escape. Near the shore, two rock bass and five bluegills were taken swimming slowly on

* I am under obligation to Mr. Chauncy Juday for identifying the alga, to Mr. J. H. Armington for the Winona Lake temperatures, and to Mr. S. L. Blue who made the field work possible.

their sides. Several small bluegills, that were still alive, were picked up stranded at the edge of the water.

Nothing is known of the summer conditions of this lake. The autumnal overturn in Eagle Lake (Winona) takes place the latter part of November. It seemed possible that there might be a deficiency in oxygen in the lower levels of the lake that was killing the fish as their actions simulated those of fish suffering from dyspnea.

An examination of the water for dissolved gases and carbonates demonstrated that the lake is a hard water lake and that there was an abundance of oxygen. (See table. 4cc. O. per liter. Temperature 6°C.) The fall overturn had taken place but the water was only about half saturated. It is barely possible that the first fish to die may have died from dyspnea, although this is not likely on account of the shallowness of the lake, the contour of its bottom, and its exposure to the wind. It is certain that the fish that were dying in November were not suffering from the lack of oxygen.

TABLE OF TEMPERATURES AND DISSOLVED GASES.

	T.	O.	% Sat.	CO_2.	Cb.
Surface	6.9	4.09	49%	1.51	42.72
2 M	6.9				
Bottom	6.9	4.06	47%	1.26	42.72

Air temperature 10°C.
Secchi's disc reading .9 M.
Gases expressed in cc. per liter. Cb. is CO_2, as carbonate.

The fish were examined very carefully for infections, sporozoan and bacterial, but the tissues showed no lesions or postules. The anus, nares, mouth, and gills were examined with especial care. There was no indication of gas disease.

It has been suggested that the lake might have been dynamited. There were no ruptured blood-vessels to indicate that the fish had suffered from concussion. Moreover, the fish were dying during a period of more than six weeks, a fact that would preclude their having been killed by a single charge of explosive.

The only prenomenon that could be associated with the death of the fishes as a causal factor was a tremendous growth of blue green alga Oscillatoria prolifica (Grenville) Dumont. This alga occurred near

the surface of the lake in enormous quantities. It was difficult to make a quantitative estimate of it by the ordinary limnological methods on account of the wind drifting it. Some notion of its abundance may be gained from the following observations:

At 10:00 a.m. there was still a very heavy fog on the lake. When rowing to the center of the lake the water appeared pink when disturbed by the oars, and in the wake of the boat. By 3:00 p.m. a slight breeze had drifted the algæ in a solid scum along the east side of the lake. In the bays this scum reached a thickness of 4-6 mm. The alga when concentrated in this scum had a rather dark brick-red appearance.

That the alga caused the destruction of the fish is probable on account of two facts. First, it is the only associated extraordinary phenomenon. This is of course only presumptive. Second, certain blue-green algæ (cyanophycæ) seem to produce substances, either by their metabolism or decay, which when concentrated are toxic to vertebrates, and may even cause death.

Arthur ('83) reports two instances in which cattle were poisoned by drinking water that was covered with a thick scum of blue-green alga (Rivularia fluitans Cohn).

Nelson ('03) after discussing the cyanophycæ that cause "water bloom" closes with these words: "In several instances it has been almost conclusively proved that the presence of one or more of these species in drinking water used by stock has caused fatal results."

Cause of the Excessive Growth of Algæ.

This lake has been under the observation of Mr. Maurice Miller for thirty-two years. He reports that this autumn (1917) is the first time that a red scum has appeared.

Olive ('05) identified this algæ from the ice in Pine Lake (Wisconsin), where there evidently had been a considerable growth just before the lake froze.

Red pigment is very characteristic of the plankton of arctic and alpine regions (Steuer 1910, pp. 277-8). The red coloration of lakes and ponds in the Swiss Alps seems to be a rather common phenomenon.

Brunn ('80) reports the ice on Lake Neuchatel being colored red with a growth of Pleurococcus palustris Küntzig. He also refers to the

freezing of Lake Morat in 1825 in which the ice was colored by Oscillatoria rufescens.

Klausener ('08) made a study of the so-called "Blutseen" of the High Alps. Most of these were colored by Euglena sanguinea Ehr.

TABLE SHOWING THE MEAN TEMPERATURES FOR OCTOBER AND NOVEMBER. DURING THE DECENNIUM 1908-1917.

Station: Winona Lake, ten miles from Huffman's Lake.

YEAR.	October.	November.
1908	54 6	42.1
1909	49.6	48.4
1910	57.2	35.8
1911	53.0	36.2
1912	54.8	41.4
1913	53 4	45 7
1914	56.7	41.9
1915	54.0	42.8
1916	53.0	41.4
1917	44.0	39.0
Mean	53.0	41.5

The appended table of temperatures* indicates that the mean for October, 1917, was 5.6 degrees F. lower than for any other October in the ten years preceding, and 9 degrees F. colder than the mean for this decennium. This means that the lake was cooled early in the autumn and remained at a rather low temperature for six to eight weeks instead of the normal, much shorter, period. That is, arctic conditions maintained in this lake for nearly two months. This is, I think, one of the factors that caused this alga to develop so luxuriantly.

Against this view, are the observations of Hyams and Richards ('01, '02, '04), and others on O. prolifica in Jamaica Pond. Here the maxima occurred in the warmer months, although a dense growth often developed just before the ice formed.

In the present state of our knowledge it is impossible to harmonize these observations with those on the so-called "blood lakes" of the Alps, those of Olive (loc. cit.) and the ones here presentd on Huffman's lake.

Brunn ('80) suggests the presence of iron compounds as one of the conditions for the development of red pigment in the blue-green algæ. This condition is satisfied by the large amounts of iron oxide in the affluent springs at its margin.

*These temperatures are for the Winona Lake Station, which is about 10 miles east of Huff man's Lake.

Remaining Problems.

It remains to be determined experimentally whether or not this alga produces a toxin, the nature of the toxin, the action of the toxin on fishes, etc.

A much more difficult problem is to determine the exact condition under which this alga will develop. If this alga reappears this problem will be attacked.

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Germinal Changes in the Bar-Eyed Race of Drosophila During the Course of Selection for Facet Number.*

Charles Zeleny, University of Illinois.

In recent discussions two explanations of the effect of selection have been offered. According to the first of these the results obtained are due merely to a sorting out of differences existing in the stock at the beginning of selection. According to the second, new germinal differences arise during the course of selection.

Among those who admit the continued production of new germinal differences there is a disagreement as to the manner in which the germinal changes occur. Some hold the view that the changes consist wholly of the production of new unit factors or genes. Others on the contrary believe that gradual change in the original genes is the principal mode of action and even that selection itself is an efficient determiner of the direction of such variation.

It is my intention to mention briefly some of the results bearing on this problem which have been obtained in the course of selection for facet number in the bar-eyed race of Drosophila ampelophila.

Bar-eye appeared in 1913 as a single mutant male in a full-eyed stock. This male gave rise to the bar-eyed stock in which the faceted region of the eye is bar shaped and the facet number is reduced from one thousand or more to about one hundred. An analysis of the hereditary behavior of bar-eye shows that it differs from full-eye in a single sex-linked genetic factor which acts as an incomplete dominant, the heterozygous condition being intermediate between bar and full-eye. My stock was obtained from Professor T. H. Morgan in January, 1914, and since that time experiments on selection for high-facet and for low-facet number have been in progress, but not in a continuous series because of loss of the lines on several occasions. In these experiments it has been shown that selection for low-facet and for high-facet number is effective, and low-bar, high-bar, emarginate eye and full eye have been produced

* Contributions from the Zoölogical Laboratory of the University of Illinois, No. 110.

from bar-eye. The analysis of the factors involved has yielded the following results:

1. Germinal diversity was present in the stock at the beginning of selection.

2. This germinal diversity was due to accessory unit factors or genes and not to differences in the bar-gene.

3. New accessory genes producing somatic differences of small degree have appeared during the course of selection. Some of these are located in the autosomes.

4. New accessory genes producing somatic differences of marked degree have also appeared during the course of selection. These also are autosomal.

5. Reverse mutation in the bar gene causing a return to the original full-eye both somatically and genetically was observed several times.

Original Germinal Diversity.

That germinal diversity was present at the beginning of the experiments is indicated by the pronounced effect of the early selections. Crosses between the high selected lines and the low selected lines show that the factors causing the difference are not sex-linked as is the main bar factor. This absence of sex-linkage shows that the difference between high and low lines can not be due to original diversity in the bar gene nor to accessory factors originally present in the sex chromosomes. The factors involved must be in the autosomes. Such differences in autosomal factors might have been present in the parental full-eyed stock from which the bar was derived. They would then have been transferred to the bar-eyed stock at the time of its formation, which involved not only change in the bar gene in a single male but also the crossing back with a full-eyed female to produce the bar-eyed stock.

Germinal Changes of Small Degree.

That the original diversity is not a sufficient explanation of the effectiveness of selection and that germinal changes continued to occur during the progress of selection in some of the lines is indicated by the continued effect of selection in these lines for many generations. It is highly improbable that a sustained effectiveness of this kind could have lasted for twelve generations, as in line V, merely as a result of the continued sorting out of an original diversity without additions to the diver-

sity due to the formation of new genes or change in old ones. After such long continued and still effective selection reciprocal crosses between high and low lines still give no indication of sex-linkage. The germinal changes of small degree which must be assumed to explain such a long continued effect of selection therefore are not changes in the bar gene nor are they due to new accessory genes occurring in the sex chromosome. New genes must have arisen in the autosomes. Experiments are under way to determine their chromosomal loci more definitely.

Germinal Changes of Marked Degree.

In the high facet selection line marked mutations have occurred which have yielded full-eyed individuals indistinguishable from the wild ones which originally mutated to form the bar stock. These new full-eyed flies are genetically of two distinct types. One type is the result of a reverse mutation involving the return of the bar gene to the original full-eye-producing condition. Its hereditary behavior is similar to that of the wild Drosophila in all the tests that have been made.

The other type retains the bar gene unchanged, the somatic appearance of full eye being due to the formation of a modifying gene outside of the sex chromosome. This new gene is effective in producing full eye when present in double dose in females heterozygous for the bar gene. Such full-eyed females when crossed with wild full-eyed males produce males half of whom are bar and females half of whom are heterozygous bar.

In males with the bar gene and in females homozygous for bar the double dose of the new gene produces an eye which is nearly full but which differs from full in the presence of a defect at the anterior margin. Such an eye may be designated by the term "emarginate." Emarginate females when crossed with full wild males give males all of whom are bar and females all of whom are heterozygous bar. The reciprocal cross gives males all of whom are full and females all of whom are heterozygous bar. Numerous tests bear out in detail the hypothesis as stated above indicating that the chromosomal formula for this type of female with a full eye is $\frac{B}{\quad} \ \frac{m}{m}$, for the emarginate-eyed female $\frac{B}{B} \ \frac{m}{m}$, and for the emarginate-eyed male $\frac{B}{\quad} \ \frac{m}{m}$. Experiments are under way to determine the exact locus of the new gene.

CONCLUSIONS.

The data obtained are of interest in a number of ways:

1. Bar-eye may return to the full-eyed somatic condition by two distinct routes. (a) Reverse mutation in the bar gene may bring the individual back to the condition of the full-eyed stock not only in somatic appearance but also in genetic behavior. (b) A similar somatic appearance of full-eye may be produced by a mutation in one of the autosomes which leaves the original bar gene unchanged, as proven by the fact that the crosses between new full-eyed females and full-eyed wild males yield low bar individuals. Change in a gene and production of new genes without change in the principal gene may produce the same result somatically. Breeding tests alone can show the difference. The change in the principal gene brings the individual truly to its original condition.

2. Both of these mutations occurring as they did in the course of upward selection furnished material of immediate value in aiding the progress of upward selection so that it is proper to say that with the aid of mutations occurring during the course of the experiment the bar-eyed mutant was returned to its original full condition. It is not intended, however, to emphasize the fact that these mutations have so far appeared only in the high line and not in the low line. Whether this is merely a matter of chance or has a fundamental significance can be determined only by further observation.

3. The genetic behavior of the type of full eye due to the addition of an accessory factor is similar to that of the individuals of the high selected line before the appearance of the mutants of large degree. The difference between high bar and low bar is due to accessory factors in the same way. In other words the accessory factors with pronounced somatic effect are different in no respect but degree from the the accessory factors with small effect which form the ordinary materials for the action of selection.

4. It is evident that with respect to this one character, facet number, three separate conditions contributed to the effectiveness of selection; first, the differences in accessory autosomal genes present at the beginning of selection; second, the new autosomal genes arising during the course of selection, and, third the mutations in the bar gene. The

original differences are comparatively of low degree, and the new autosomal genes represent in some cases small differences in somatic appearance and in one case a large difference. The mutations in the bar gene so far have been of large degree in all cases, bringing the bar stock back to its original condition.

5. The demonstration of all three of these modes of producing an effective selection in the case of a single character indicates clearly that the selection problem and with it the problem of stability of the unit factor or gene is not capable of solution by any single formula.

DWARFING EFFECT OF ATTACKS OF MITES OF THE GENUS ERIOPHYES UPON NORWAY MAPLES.

HOWARD E. ENDERS, Purdue University.

The peculiar dwarfed and somewhat blighted condition of a portion of the branches of Norway maple trees in and about the town of Hershey, Pennsylvania, attracted my attention during August of 1917, and an effort was made to determine the cause of this condition. The gen-

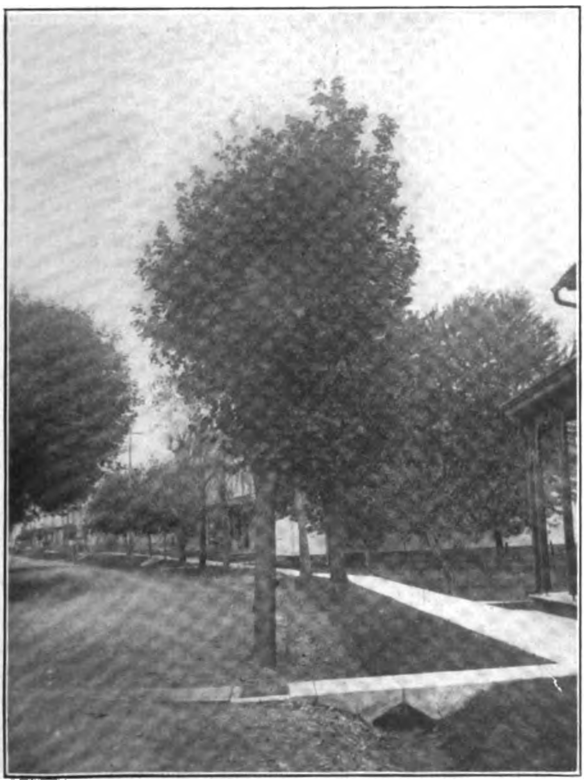


Fig. 1. Norway maple infested with mites (Eriophyes) for a period of at least three years. Its stunted growth is suggestive of excessive trimming.

eral appearance (Figure 1) of the trees seemed to indicate that they had been heavily pruned one or more seasons ago. They were greatly branched in a manner suggestive of the excessive branching often seen in the "witches' brooms" on the hackberry.

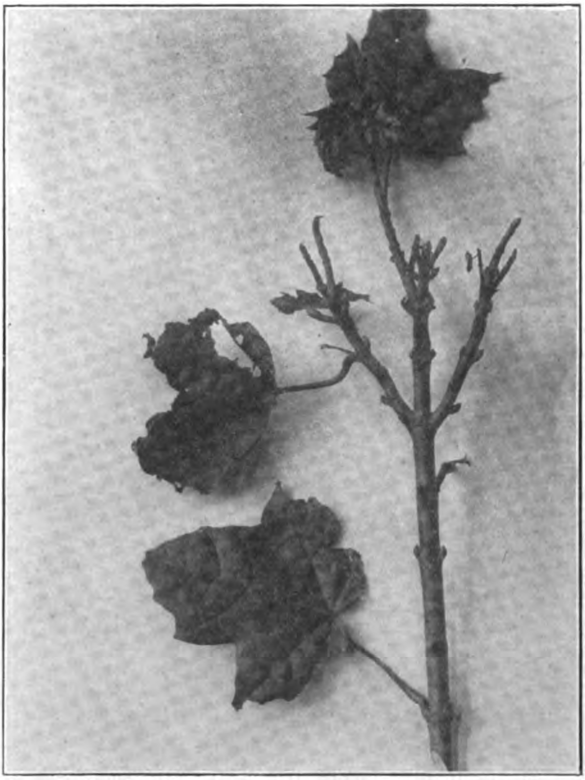


Fig. 2. Short branches of infested Norway maple, partially defoliated to show the dwarfed condition of foliage and stems.

At the time of observation a portion of the terminal branches bore some foliage that was green but many of the leaves were small and brown-edged, while others had become wholly brown in the affected regions. A weak post-season growth of an inch or thereabout had occurred in which the young tender foliage was expanding in an apparently normal manner. This type of post-season growth was quite sim·

ilar to that reported by Miss A. M. Taylor in 1914 (Journal of Agricultural Science, Vol. 6), as characteristic of gooseberry—*Ribes grossularia*—in England, infested with *Eriophyes ribis* (Nalepa). In the plants which she studied she found that after the first effects of the attack by

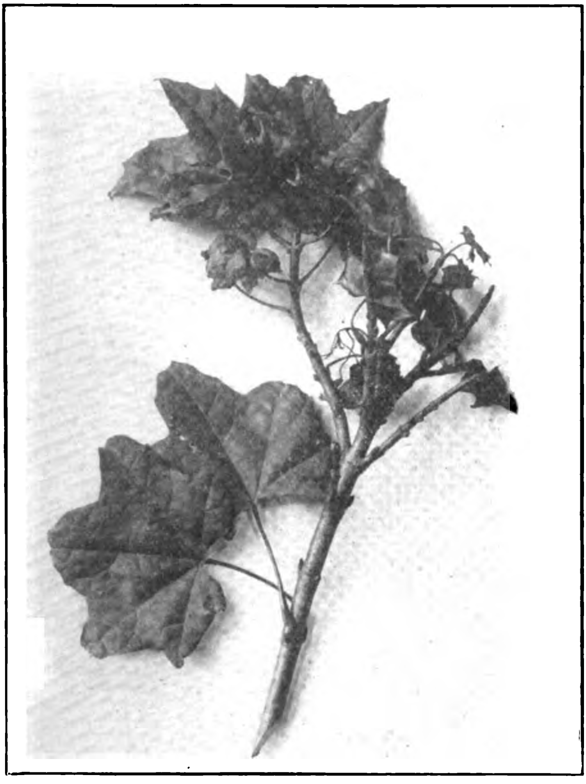


Fig. 3. Short branches of infested Norway maple, partially defoliated to show the dwarfed condition of foliage and stems.

Eriophyes were overcome the later growth of foliage and wood was apparently normal, though many of the early leaves bore "blisters" that ranged from single to more or less confluent masses.

The maples, however, seemed not to recover until too late in the season to make a marked growth. The foliage bore no malformations, blisters, typical erineums, or galls that would indicate the cause of in-

jury. It was observed that many of the leaves bore numerous trichomes on the under surface at the proximal portion of the laminæ where the veins converge toward the petiole.

Large numbers of mites, identified as Eriophyes sp(?),* were seen to crawl from beneath and among the trichomes when the point of a teasing needle was drawn through these regions. When the mites are thus disturbed they crawl rapidly over the under surface of the leaf, or

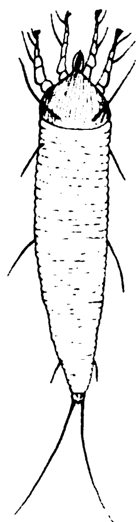


Fig. 4. *Eriophyes vitis* from Banks, in "The Acarina or Mites." It is here reproduced to indicate the generic character of the maple mites rather than the specific characters.

stand on end and, attached by the caudal adhesive disk, sway the anterior end of the body in a circle; others seem to make a leap, and disappear from sight. No effort was made to determine the relative number on each infested leaf, but it was estimated to be a hundred or more for the many leaves that were examined.

During the cooler hours of the morning the mites were to be found

* The author has not found it possible to procure satisfactory material for drawings, since his interruption in the observations, therefore, a drawing of *Eriophyes vitis* by Banks (in Report No. 108, Contributions from the Bureau of Entomology, U. S. Dept. Agr., Washington, D. C., 1915, on "The Acarina or Mites"), is introduced to indicate the character of the mites, rather than the species, which infest the Norway maple.

among the trichomes of the leaves, but during the warmer periods of the day a few were found usually crawling about the under surface of the leaves, chiefly close to the main veins.

Foliage was examined after a light frost late in August, and again after a killing frost early in September. In the first instance relatively few mites remained among the trichomes, and after the killing frost none were found on the leaves, but a much smaller number—ten to twenty—was found in the axils of the leaves, and around the young buds where they seem to have taken shelter. Three instances were observed in which a single mite, and another in which two, had pressed into the young buds, just beneath the outer scale-leaves.

An unexpected interruption in the observations made it impossible to trace the effect of cold upon the mites, and to study their method of passing the winter, if it actually occurs. Twigs collected through the kindness of Mr. Charles Gemmill, student in Lebanon Valley College, Annville, Pennsylvania, were sent me early in October, but I was unable to locate the mites in any of the buds, or in the axils of such leaves as remained attached to the twigs. None of the buds showed any swelling or enlargement that could suggest the "big bud" similar to that observed in the black-currant infested with *Eriophyes ribis* (Nalepa). Miss Taylor (Jour. Agri. Sci., Vol. 6) in 1914 described the enlargement of buds on black-currant in England, when so infected. In that instance the mites penetrate the buds, causing them to swell, and if badly infested, to die without opening. She found the mites to breed throughout much of the year, and to migrate in the spring when the buds are opening. This may be suggestive of the possible mode of hibernation of *Eriophyes* (species undetermined) in the maple, but without producing hypertrophy of the buds.

Similar stunted growth of Norway maples was observed in other towns, and occasionally along the highways of Lebanon and Dauphin counties in Pennsylvania, in sufficient numbers to suggest a wide dispersal of these mites through the agency of birds or insects rather than by the wind. English sparrows crowded into the trees in large numbers in Hershey, and it is quite possible that they may carry many of these small mites on their legs and body, from tree to tree, and even from village to village in their migrations.

Though the trees showed no very serious ill effects from the attack

of 1917, it was apparent that growth had been retarded and that subsequent attacks would mar their beauty permanently. An extreme case of injury by mites is clearly indicated in the accompanying photographs (Figures 1, 2, and 3), of a tree and branches which have been infested for a period of at least three years.

The remedies which Professor Slingerland found effective for mites that attack other plants may prove effective on the maple. He has found that they can be exterminated by spraying trees in winter with kerosene emulsion diluted with five to seven parts of water. This will penetrate buds and kill the mites which hibernate there.

Where the Feeble-Minded Are Self-Supporting.

Hazel Hansford, Indiana University.

It has long been recognized that many of the feeble-minded can be made self-supporting in a relatively simple environment if properly trained for the things which they can best do. This is being done for a small number of these unfortunates in some of our institutions. The boys are being taught wood work, farming under supervision, while the girls learn to cook, sweep, and to do many other simple household tasks. In this way they earn their keep, whereas if turned loose in the world, most likely they would become dependents.

Very little is being done in the way of educating our mental defective to earn his own living. Our state law compels him to attend the public schools until he is sixteen, where he studies the same things as the normal children. He remains in each grade for two or three semesters, or until the teacher is tired and is ready to push him onto the next instructor. As a result he ends up in the fourth or fifth grade with nothing in his head to show for his long years of wasted time, the wasted time of the teacher, and the other pupils. He knows no arithmetic, grammar, or history. All has gone into one ear and out of the other. He is turned loose with no training. He and his brothers and sisters go into unskilled labor, maybe. Sometimes their life-long profession of idleness begins immediately. If they are lucky enough to reside some distance from town, they will probably get by as farm tenants—the kind that moves to a new place every year.

For some time the writer has been making a study of a family of mental defectives and it has been interesting to note the kind of occupations common to the different groups within the larger group. To give some idea of two of these groups and their characteristic employments, some facts concerning the family will be given very briefly.

About 1798 there came from Virginia to Kentucky a man whom we will call John Jones. We know little about him except that he hunted most of the time. His family raised corn, part of which was made into cornmeal, and part into that beverage for which the Kentucky mountains

are famous. He had eight children all of whom lived and died in or near the old homestead, except two, who came to the southern part of the State of Indiana. About all the descendants of children numbers 2, 4, and 7 are still living in the Kentucky mountains from twenty to fifty miles from a railroad. The descendants of child number 5 settled in Orange County of this State. The descendants of child number 1 are in two groups, the legitimate and the illegitimate. The former are also in the mountains while the descendants of the illegitimate are in Indiana. In 1856 the illegitimate son of number 1 came here to live. He and his family left their home because they could no longer make a living there. For two years the crops had failed to grow and no corn had been raised to make their bread and mush. Other people have said that it failed to grow because the family was too shiftless to tend it. The man and the three older children walked, while the wife and the two younger ones rode on an old broken down mule. He carried an iron skillet in his hand and when night came, he would cook what he could find or beg. Haystacks, barns, and sympathetic country folks furnished lodging. In this manner they finally reached the south-central part of Indiana.

There they made their home, and from that time until this they have rapidly multiplied and degenerated until their name is a synonym for shiftlessness. Eight more children were born in rapid succession, the last six of whom the mother never saw because of blindness. The descendants of these thirteen children form the first group, of whose occupations I wish to speak.

They live in or near a town of about 12,000 in the south-central part of Indiana. There is plenty of work in this town for unskilled laborers in the factories, stone quarries, and on the streets. But in spite of the fact that there is plenty of work, the majority of the Joneses are unemployed most of the time.

Those above the age of fifteen years have been used for the following figures: Out of fifty-seven men and women, fifty-four are feeble-minded. They have been found to be so in one of the three following ways: (1) by a formal examination in the laboratory; (2) by a judgment of the field worker where the condition was so apparent that no examination was necessary, and (3) where the person has been judged feeble-minded by his reaction to society. The normal individuals of Jones blood are the result of marriages into fairly good families, and

each of these have normal consorts. They are self-supporting and do much to keep some of the relatives from becoming entirely dependent on the community.

Of those fifty-four feeble-minded men and women, thirty-four have received poor relief for the greater part of their lives; in poor relief I include also the poor asylum cases; ten have served sentences, and one has spent most of his life in an insane asylum. Four of the fifty-four have worked regularly, the other fifty only when the spirit moved them.

Fifteen have no occupation at all.
Seven do odd jobs.
Six are fairly good housekeepers.
Four are farm tenants.
Three work in factories as unskilled laborers.
Three are housemaids.
Three are prostitutes.
Two are washerwomen.
Two are stone quarry laborers.
One was a brakeman.
One is a wood cutter.
One is a barber.
One is in a slaughterhouse.
One is a well cleaner.
One is a street cleaner.
One is a hod carrier.
Seven per cent. of these are entirely self-supporting.
Twenty-nine per cent. are non self-supporting.
Sixty-three per cent. are partly self-supporting.

The simplest environment in which we find the Joneses living is down in the Kentucky mountains where living conditions are of the most primitive to be found. The district is so far from a railroad and the roads so nearly impassable that they have never been far from their homes. They raise all they eat and eat all they raise, or let it waste, because there is no market. So there is no incentive for folk to be ambitious, but to work just enough to feed and clothe themselves. On the other hand, it is necessary that they do have the needful things of life, for there is no

kindly poor relief law to care for them, and oftentimes they are living so far from neighbors that they could starve before help would arrive.

Eighty-one adults who are, or should be, earning their living represent this group. Of this number fifty are feeble-minded and thirty-one are normal. The normal cases will be eliminated as they were in the Indiana group. Of the fifty feeble-minded people:

Sixteen have no occupation.
Fifteen are farm tenants.
Eight help at home.
Five are farmers.
Two hunt gingseng.
Two are bootleggers.
One is a prostitute.
One does odd jobs.
Total, 50.

Six of those listed as having no occupation are not dependents in the real sense of the word. They manage to live without work, but also without begging. They gamble, steal, and hunt. One entire family lives mostly on the squirrels the men are able to kill. Oftentimes their aim is so poor that they miss the squirrels and kill sheep. The remaining ten who are non-self-supporting, are idiots and imbeciles, who could not care for themselves in any environment, so this 20 per cent. is not really comparable to the 29 per cent of non-supporting individuals in the Indiana group. The people whose mentality was of the same level as the Indiana paupers, were all self-supporting in the simpler environment. And if we exclude those idiots and low grade imbeciles, we have no non-self-supporting mental defectives to compare with those of Indiana.

It may be that the simple environment is not responsible for these figures, but there are other instances where the feeble-minded are self-supporting in a relatively simple environment. In some of the European countries where the work history of a man is pretty well determined when he is born, and where he is bound by certain industrial conditions which we do not have here, there is less unemployment, tramps are fewer, and there is very much less unrest and changing about than among our subnormal laborers. In the institutions which are run on the colony plan, the inmates are taught to do certain things well, and are kept at

those particular tasks by the men in charge. It is now the dream of some of the men interested in the problem of the care of mental defectives, that in the near future we can have large farms or colonies where these people can be kept at work, protected from the complex conditions of the outside world which they are unable to meet. And this will make it possible for them not only to take care of themselves, but to relieve society of the burden placed upon it by the crimes and other social evils to which this class is naturally addicted.

A Study of the Action of Bacteria on Milk Proteins.*

George Spitzer and H. M. Weeter, Purdue University.

It is generally recognized that most bacteria have an action on organic food material which is characteristic for different species and is influenced by their previous environment and the kind and relative proportion of the different foods in the media. As the food and water requirements of higher plant and animal life and of bacteria are similarly related, bacterial metabolism involves the change which the food materials undergo by virtue of bacterial action and is determined by the properties and composition of the end products. With the present chemical methods of analysis it is possible to determine with considerable degree of accuracy the initial composition of the bacterial foods, also the end products. Of what takes place within the organisms little is known. Inferences can only be drawn from the changes in the medium and the nature of the enzymes secreted by the bacteria. When bacteria are grown in a medium containing both proteins and carbohydrates it has been found that the cleavage products are modified, depending upon the source and chemical complexity of the protein and carbohydrates.

B. Coli, when grown in a nitrogenous medium in presence of easily fermentable carbohydrates, fails to produce indol or the production of indol is extremely rare, but when B. Coli is grown in a medium containing the same nitrogenous foods in presence of carbohydrates which do not ferment readily indol is produced. The character of the proteins likewise influences the growth and metabolism of bacteria and the cleavage products are not of the same kind and character. The proteins are hydrolized by bacterial enzymes into simpler complexes, such as proteoses, peptones, and possibly peptids and amino acids.

There is a marked difference depending on the source of nitrogen, and a still greater difference depending on the species of bacteria, in the production of cleavage products. According to Taylor (Ztschr. f. Physiol. Chem., Vol. 36), B. Coli digests casein mainly into proteoses and peptones with the formation of only a small per cent. of amino acids,

* "Contribution from Purdue University Agricultural Experiment Station, Department of Dairy Husbandry."

while when grown in egg meat mixture according to Rettger (Journal Bio. Chem., Vol., 13), this same bacterium produces profound changes, giving indol, skatol, and amino acids.

Also, the utilization of any of these simpler nitrogenous products of hydrolysis depends upon the life history and the species of the bacteria and of food material other than the nitrogen compounds; that is, carbohydrates, salts, etc. Concerning the utilization of the amino acids, under certain conditions the basic amino acids or diamino acids are used to a greater extent as a source of nitrogen instead of the monoamino acids, and the reverse may happen; the monoamino acids are used more readily and fail to appear in the final products.

From our own work during the past year on bacterial metabolism, unpublished data are at hand showing the utilization of the amino acids. Lots of 500 c. c. of sterile milk were inoculated with pure cultures of B. proteus, B. liquifaciens, B. subtilis, and B. megatherium. These lots of inoculated milk were stored at room temperature for six months. The nitrogen distribution was then determined, ammonia, melanin, amino acids, etc.

The following table shows the per cent. of monoamino and diamino acids obtained upon hydrolyzing the milk before inoculation, also the per cent. of the same amino acids after inoculation for six months.

TABLE I.

	Sterile Milk.		At End of Six Months' Incubation.	
	Monoamino Acid N. %	Diamino Acid N. %	Monoamino Acid N. %	Diamino Acid N. %
B. proteus	56.50*	23.66	42.14	5.61
B. liquifaciens	56.50	23.66	45.02	5.82
B. subtilis	56.50	23.66	54.14	7.61
B. megatherium	56.50	23.66	40.00	7.24

*Per cent. of total nitrogen.

In Table I the relative proportion of the utilization of the two groups of amino acids is shown for the four different bacteria. It will be noted that the diamino acids are used in greater amounts than the monoamino acids.

Table II shows the per cent. of the total monoamino and diamino acid nitrogen utilized by the four bacteria calculated from Table I.

TABLE II.

	Monoamino Acid N. %	Diamino Acid N. %
B. proteus	25.42	76.29
B. liquifaciens	20.32	75.40
B. subtilis	4.17	67.83
B. megatherium	29.15	69.40

In general, this is in agreement with the work of Robinson and Tartar (Journal Bio. Chem., Vol. XXX, page 135). However, this comparison can only be roughly made since their medium consisted of an aqueous soil extract plus a nitrogenous food material; i. e., fibrin, pepton, egg albumen, gliadin, and casein, with a small amount of carbohydrate in the form of mannite and synthetic solution of salts in addition to the salts extracted from the soil.

The pure cultures used by Robinson and Tartar were B. mycoides, B. subtilis, and B. vulgaris. The above facts concerning the utilization of the amino acids by bacteria are in harmony with the work of most investigators on bacterial metabolism. No doubt the utilization of the amino acids is influenced by the character and quantity of proteins and carbohydrates present in the media. We know, if carbohydrates are absent or hydrolyzed into compounds which do not yield the desired food material—namely, the carbon—as readily as the original carbohydrates, bacteria must necessarily derive their carbon supply from the protein or amino acids. There is no quantitative relation connecting the increase of acidity with the loss of carbohydrates by bacterial action on the respective carbohydrates. So some of the carbohydrates must be used in supplying energy to the organisms.

About six years ago, while the senior author was conducting an extensive investigation concerning the keeping qualities of butter when placed in cold storage, the results of the investigation suggested to him the advisability of taking up a systematic study of pure cultures of known bacteria in a medium composed of milk proteins in presence of carbon compounds such as lactose and lactic acid, etc.

By pursuing this method of investigation it will be possible to arrive at more definite information regarding the bacterial action on milk proteins and the character and quantity of the final cleavage products. The

selection of the respective bacteria are those frequently found in milk, cream, and butter. By the selection of these bacteria and using a medium which is naturally present in milk products, we are able, in a great measure, to avoid introducing disturbing factors on the end products, also factors foreign to our previous work concerning the changes produced in stored butter.

Our preliminary study included the following bacteria: B. proteus vulgaris, B. viscosus, B. butyricus, B. mycoides, B. lactis acidi, B. mesentericus, B. liquifaciens, B. fluorescens putidus, B. subtilis, B. megatherium, and B. coli. The medium was sterilized milk to which the pure cultures were added and kept at room temperature. The pure cultures were previously grown in the same media and transfers were made three times before being used for experiment. At intervals of three days an analysis of the inoculated milk was made. The following products were determined each time the analysis was made: acidity, aldehyde number*, lactore (polariscope), ammonia (Folin's method), and nitrogen compounds not precipitated by phospho tungstic acid. This was continued for five periods or during a period of sixteen days. (First period four days.)

The following table shows the changes in the nitrogenous constituents of the milk and the change in lactose by the different bacteria at the end of the sixteenth day.

TABLE III.

Showing the per cent. of gain of ammonia (NH_3) and amid nitrogen based on total nitrogen and the loss of lactose based on the total lactose.

	Ammonia (NH_3), N. % Gain.	Amid, N. % Gain.	Lactose, % Loss.
B. proteus	5.42	1.63	27.65
B. viscosus	11.01	22.13	50.30
B. butyricus	4.49	6.59	23.04
B. mycoides	10.28	8.38	14.84
B. lactis acidi	2.04	1.88	34.87
B. mesentericus	10.28	12.38	62.92
B. liquifaciens	20.20	25.63	60.00
B. fluorescens putidus	1.46	2.13	17.83
B. subtilis	12.10	22.84	47.10
B. megatherium	7.34	24.64	54.11
B. coli	3.66	3.63	17.63

* The aldehyde number gave no more information concerning protein hydrolysis than did phospho-tungstic acid.

Ammonia, amid nitrogen, lactose, and acidity were estimated in the sterile milk before inoculation for the purpose of comparison. This gave for lactose 4.99 per cent., total nitrogen .56 per cent., and acidity .17 per cent. as lactic acid. Ammonia .89 per cent. and for amid nitrogen 2.87 per cent. based on total nitrogen present in the sterile milk.

The changes in acidity for the different bacteria are shown in Table IV.

TABLE IV.

Showing changes in acidity, expressed in per cent. of lactic acid, during the period of sixteen days.

	Per Cent. Lactic Acid.
B. proteus	.027
B. viscosus	.324
B. butyricus	.180
B. mycoides	.261
B. lactis acidi	1.161
B. mesentericus	.459
B. liquifaciens	.909
B. fluorescens putidus	.045
B. subtilis	.468
B. megatherium	.360
B. coli	.135

Comparing Tables III and IV, it is shown that the acidity of the milk medium is not in proportion to the loss of lactose, nor gain in ammonia. Therefore neither the production of ammonia nor the acidity is an exclusive measure of the activity of the organisms. It has been stated that the production of ammonia is an index of the metabolic activity of the organisms. This must be taken with some qualification inasmuch as proteolysis does not take place by leaps; that is, that the different cleavage products are produced in regular order, as proteoses, peptids, amino acids, etc., but it is more natural and in harmony with enzymic action on proteins and carbohydrates, that as soon as proteolysis begins, a series of simpler compounds are formed and all the cleavage products appear, the proportion depending upon the medium, kind of organisms, and enzymes produced by each specific bacterium. Since it is possible to measure the production amino acids and ammonia at short intervals with a good degree of accuracy, it has given additional evidence to show the mode and rate of the activity of bacterial metabolism and their proteolytic power.

Of the eleven bacteria studied there was a continual change in acid-

ity from the first period until the last, except the lactic acid bacillus which produced its maximum acidity within the first period (four days) which was 1.61 per cent. as lactic acid. No change in acidity occurred after this period, nor was there any increase in ammonia. The amid nitrogen increased slightly at the expiration of four days and there was a agin of amid nitrogen of .0077 per cent. and at the expiration of the sixteenth day there was a gain of .0105 of amid nitrogen, a gain of .5 per cent. on total nitrogen, showing a continual proteolytic action due either to enzymes or auto-proteolytic digestion.

It may be noted that some bacteria utilizing the larger amount of lactose were also quite active in the production of ammonia and amino acids. On the other hand, in Table III the fermentation of lactose was proportionately greater than the production of ammonia and amino acids by B. proteus, B. butyricus, B. mesentericus, B. fluorescens put., and B. Coli.

We hope to study further the action of these organisms in pure culture on nitrogen from different sources, the effect of carbohydrates and also the associative action of these cultures on milk proteins.

PLASTIDS.

D. M. MOTTIER, Indiana University.

(Abstract)

The major part of the results of an extended study on plastids and similar bodies in cells of various plants, of which the following is an abstract, has been published in the Annals of Botany, Vol. 32, pp. 91-114, 1918.

The investigation was concerned chiefly with the origin of leucoplasts and chloroplasts from their primordia, as found in meristematic cells. The primordia of leucoplasts and chloroplasts appear as very minute, granular or rod-shaped bodies, which multiply by direct division. From such primordia, leucoplasts develop as rounded or pear-shaped bodies with the starch inclusion accumulating within. In case the primordium is rod-shaped, the leucoplasts, in such tissues as the root tip of *Pisum*, take on the form of a hand mirror with the inclusion in the larger end.

In certain typical cases the primordium of the chloroplast may first become lenticular with a pale center and a densely-staining periphery. With further growth they finally assume the form present in the adult plant organ.

Morphologically the primordia of leucoplasts and chloroplasts are precisely alike. It may be of interest to note that the morphological identity of leucoplasts and chloroplasts was pointed out by A. F. W. Schimper about thirty-eight years ago. The following is a translation of his summary (Bot. Zeit., p. 899, 1880): "The results of this brief study show that the deep chasm hitherto supposed to exist between the starch formers in assimilating and in non-assimilating cells does not, in fact, exist. In cells free from chlorophyll there are definite organs which generate starch, and these organs are none other than undeveloped chloroplasts (Chlorophyllkörner), which under the influence of light are able to develop into the latter. On the other hand, chlorophyll grains are not always organs of assimilation merely, but they may, in the conducting tissues and in cells which contain reserve material, function as starch

formers in the non-assimilating cells; they produce starch from assimilated materials supplied by other parts of the plant."

It may be stated also that the origin and formation of starch grains as described by this brilliant Alsatian was essentially correct, as later studies of others have shown. At that date the technique which now so clearly brings out the primordia of plastids was unknown.

In the aleurone layer of the endosperm of *Zea Mays*, the primordia of the aleurone grains are first recognized as very minute, rounded granules which may stain densely and uniformly. As they increase in size, they become globular with a smooth and sharply-defined contour and reveal a pale or colorless center. They may be represented by making a minute circle with a pencil. As they become older, they increase in size and usually take on a pale yellowish or orange color with the stains used.

It may be remarked also that the starch grains in the endosperm of *Zea* originate in a similar manner and from primordia that are indistinguishable morphologically from those of the aleurone granules, with the difference that in the case of the leucoplasts the starch inclusion stains blue with gentian violet.

In addition to the primordia of the plastids mentioned, other similar though smaller bodies are present—frequently in very large numbers in the cells—which do not become either leucoplasts or chloroplasts. To these I have confined the term *chondriosome*. Such chondriosomes are especially well demonstrated in cells of the liverworts, *Anthoceros* or *Marchantia*.

The conclusion reached is that the primordia of leucoplasts and chloroplasts and the bodies here designated as chondriosomes are permanent organs of the cell, having the same morphological rank as the nucleus.

The function of chondriosomes is not known. It is generally conceded that they are concerned in certain metabolic activities of the cell. Being definite organs of the cell, they may be regarded also as playing some part in the rôle of heredity.

VARIATION AND VARIETIES OF ZEA MAYS.

PAUL WEATHERWAX, Indiana University.

Indian corn is commonly known to be a very variable plant, and any farmer can name off-hand from a dozen to fifty more or less definite varieties. Many attempts have been made to dispose of the plant in a technical way by naming, describing, and classifying these varieties, but the layman, and even the botanist who has not made a special study of the subject, is much in the dark as to what nomenclature is advisable in speaking scientifically of corn. To point out briefly the range of variability of the plant and to discuss critically some of the technical names that have been applied to the varieties of corn is the object of this paper.

In all parts of the maize plant there is a striking variability of size. I have grown healthy plants in a normal environment which were eighteen inches tall at maturity; and plants twenty-four feet tall have been reported. Some plants have stems no larger than a lead pencil, and the stems of others measure six inches in circumference. The leaves and other vegetative parts vary proportionately.

Stalks of most varieties bear only one or two ears, but as many as ten well-developed ears have been seen on a single stalk. An ear may have from four to thirty rows of grains, and there is as great a variation in the number of grains in a row.

The fruit of the plant, being the economic part and the part best known, has been made the basis of most classifications. The pericarp varies from white through shades of pink, red, and yellow to a dark brown, and definite color patterns in the form of stripes are common. The endosperm is usually characterized by the development of a large amount of starch, but in sweet corn the starch is partly replaced by another carbohydrate. In physical character the endosperm is partly soft and partly corneous, and these parts have a more or less definite ratio and arrangement in each variety. The soft portion is always white; the corneous part may be white or yellow. The aleurone is white, red, or blue to black, and mixtures of either of these colors with white occur in definite patterns in some varieties. The largest grain I have ever seen

weighed fifty-six times as much as the smallest. The fruits of most varieties are naked, except for the well-known covering of husks, but there is a variation from this in the podded types, each grain of which has a separate covering composed of the enlarged glumes and palets.

Still further illustrations of ordinary variability might be mentioned, but these will suffice. Besides these, there are some less common variations—sometimes termed mutations and sometimes reversions—which add interest to our investigations but complicate our classifications. A few examples may serve as illustrations. The production of male elements in female inflorescences or female elements in male inflorescences is of common occurrence, and varieties breeding true to these characteristics have, in some instances, been isolated. Emerson has a variety whose leaves have no ligules, and another—a dwarf variety—whose ears bear hermaphrodite flowers. Gernert has isolated a constant strain whose ear is a loose panicle.

The difficulty at the bottom of any attempt to classify the varieties of maize is in the perplexing lack of correlation between these variant characteristics. Some authorities maintain that definite correlations do exist, and others are as confident that they are almost if not quite independent of one another. The merits of either argument is irrelevant to our present consideration. That certain physical correlations do exist is accepted without argument, but all the genetic correlations that have ever been discovered are of little avail in classification. If the various characters had a tendency to remain in groups affording rigid types, a basis for classification would be provided; but, in a practical way, it seems possible to combine in a single plant or to separate at will any two characteristics which are not connected in any physical way, allelomorphs of course being excepted.

Pure botanists, as well as those prompted chiefly by a utilitarian motive, have taken their turn at the problem, and many articles have been published by experiment stations and other institutions. Without going into details, we might analyze the principles employed and see what progress has been made.

I have made no attempt at a thorough investigation of the tribulations through which the maize plant originally passed in getting itself named. Suffice it to say that all that we usually call maize or Indian corn passes technically under the name *Zea Mays* L., the generic root

being the Greek name of some cereal, and the specific a corruption of an Indian name for the plant.

When a distinct variation from the described limits of a species is found, it is customary to make of it a new species or to include it as a variety of the parent species. Both systems have been applied to maize. Sturtevant adopted the plan of a trinominal nomenclature to distinguish seven varieties, as follows: *Zea Mays tunicata*, pod corn; *Zea Mays saccharata*, sweet corn; *Zea Mays indentata*, dent corn; *Zea Mays indurata*, flint corn; *Zea Mays everta*, pop corn; *Zea Mays amylea*, soft corn; and *Zea Mays amylea-saccharata*, a poorly-defined type, part soft and part sweet. Some later authorities have dropped the word *Mays* from these names, giving the types specific rank.

The inadequacy of either system is obvious on close examination. It is based upon a single set of characteristics, and in other respects each variety or species is subject to the full range of variation. In fact even these seven varieties are not distinct with regard to the set of charactristics which forms the basis of division; pod corn necessarily exists in one of the other six forms or in a mixture of them. The name of a species should stand for a description; its value is lessened as exceptions to this description are found, and utterly destroyed as soon as it overlaps other species so far as to render them indistinguishable. If the names stand for nothing but individual characters, then, it would be better to mention the character than the variety possessing it. There is also another disadvantage to the system; it establishes a bad precedent, which, with a little encouragement, would soon lead to a condition bordering on absurdity; in fact, I am not sure that it has not already reached that point. Upon this basis a number of new variety names have already sprung into existence, and more are due to arrive at any time. Blaringhem mutilates a corn plant and gets, or thinks he gets, as a result, a number of new varieties which breed true. To these he gives such names as *Zea Mays praecox*, a very precocious form indeed if we accept his interpretations, and *Zea Mays pseudo-androgyna*, *pseudo* because a *Zea Mays androgyna* already existed. Although his methods and conclusions are a trifle shady, his naming of the new forms illustrates the point in question. Seed companies advertise *Zea gracillima*, *Zea Mays gigantea quadricolor*, *Zea japonica*, and *Zea Curagua;* and the Department of Agriculture is now offering for distribution through the

Office of Seed and Plant Introduction a new discovery, *Zea guatemalensis*, which seems to be ordinary corn from Guatemala. Besides these we have a *Zea Mays chinensis* and a *Zea Mays pensylvanica*, and in this way we might continue until we run out of habitats and combinations of characteristics. Gernert's Branch Corn was hailed as a new seventh species, *Zea ramosa*. Emerson might have named his liguleless variety *Zea Mays aligulata* and his dwarf variety *Zea Mays pygmea-androgyna*, and Stewart or the writer might, on discovering the two-flowered condition of the female spikelets of Country Gentleman sweet corn, have reveled in the invention of some such name as *Zea Mays saccharata geminata*—but none of us did. The difficulty is not in finding new varieties or in naming those found, but in avoiding being led to more ridiculous ends—in stopping the naming process soon enough to permit a name to mean anything; for when anyone has made a complete list of all the varieties that he knows, someone else can always add a few more that he knows, or, if need be, make a few to order by judicious hybridization.

The cause of this confusion is easier to find than is its remedy. It lies in our limited knowledge of the evolutionary history of the plant. No wild form of corn has ever been seen by civilized man. When America was discovered, the plant cultivated by the Indians was almost as complex as it is today. We can, however, imagine the evolutionary process reaching a place where its product was a plant of more or less uniform character agreeing with the generic description of *Zea*. Further evolution, aided by reversion, then proceeded to produce in isolated environments a number of varieties possessing in definite combinations the various characteristics already mentioned. If we knew what these combinations were, we should have a basis for naming varieties. But the plant readily hybridizes with other varieties of its kind, and these different original types, brought together and mixed by the savage or semi-civilized agriculturist, gave us the heterogenous combination that we know corn to be. It is probably safe to say that there exists nowhere in the world today a primary variety of corn that has not been complicated by hybridization with some other variety. Hybridization with teosinte, one of the nearest relatives of maize, has added further difficulties in the tropics, and it is probably due to the limited habitat of teosinte as compared with that of maize, that the dividing line between the two genera has not long ago been obliterated. Few other plants, wild or cul-

tivated, present these difficulties, because few others combine such a range of variability with such ease of hybridization.

I am fully aware that some of these latter remarks are not in accord with the commonly accepted theory of the hybrid origin of maize, but I do not believe that theory to be the correct explanation of the origin of the plant. My full discussion of that point will be presented elsewhere.

A specific name is to be understood as only an abbreviated description, and the only thing about maize that is constant enough to have a fixed description is the whole genus. It is true that in some variations it borders closely upon some other genera and even encroaches upon the territory allotted to another tribe of grasses, but its limits are sufficiently definite to obviate any doubt as to whether or not a plant under observation is corn.

The best taxonomic treatment, then, seems to be to consider *Zea* a monotypic genus and discard all other names than *Zea Mays* L. Reference to the numerous variations can be made to the characteristic directly and not to any arbitrary variety possessing that characteristic in varying combination with other properties.

IMPROVED TECHNIQUE FOR CORN POLLINATION.

PAUL WEATHERWAX, Indiana University.

Many devices have been described for the control of pollination in various plants, and a number of these have been found especially serviceable in the extensive work that has been done in corn breeding. The best points of two or three of these methods have been combined and used successfully during the past year.

The protection of the female inflorescence is made of an 8x12 sheet of typewriter paper. Its construction can best be explained by reference to the accompanying diagram. (Fig. 1.) Half an inch along one end of the sheet is folded over and pressed down along AA; one side is similarly folded along BB, and the other along CC. One of these latter folds is glued down to the other, and the result is a long, flat envelope, open at both ends and reinforced at one end by the half-inch fold.

The glue employed may be any of the common brands that are purchased ready for use; this can be rendered almost insoluble by the addition of a small quantity of any readily soluble chromate and drying the pasted article in sunlight. To make the envelope waterproof, a solution of hard paraffin in benzole is applied with a tuft of cotton. The evaporation of the benzole leaves the paper dry and smooth but impregnated with paraffin.

The manipulation of the device is simple. It is usually best to remove the lamina of the leaf in whose axil the ear is borne and to slit its sheath down the sides. The reinforced end of the envelope is then slipped over the ear and made tight by means of a tuft of cotton stuffed in from below. The top of the envelope is folded over and fastened with a paper clip, which is tied loosely to the stem of the plant. (See Fig. 2.) When the silks have appeared, the clip is removed without untying from the stalk, the pollen poured in, and the clip replaced.

As the ear continues to grow, the string by which the clip is tied slips upward on the stalk, and little further attention is required. The tuft of cotton is compressed to make room for the increasing thickness of the ear, until the latter is large enough to burst the envelope without injury to itself. By this time the silks are usually no longer receptive.

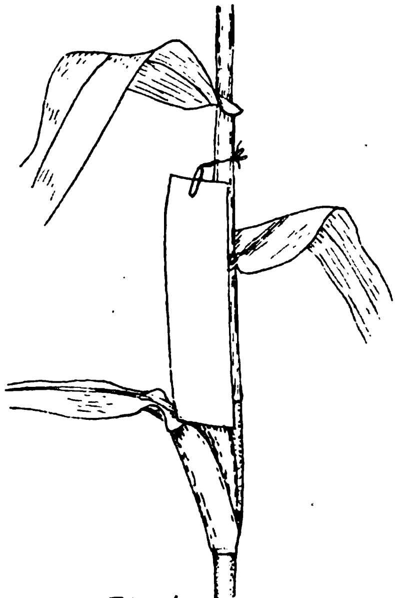


Fig. 1

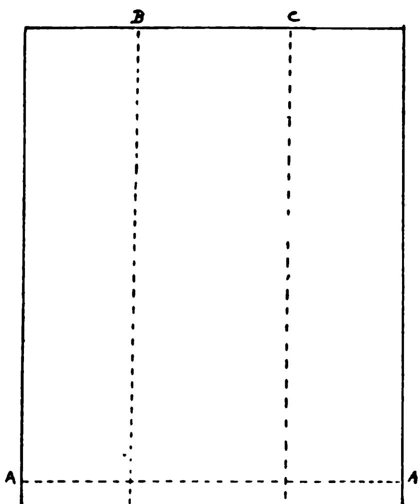


Fig 2

Technique for corn pollination.

The best method yet found for collecting the pollen is by means of ordinary paper bags, the size depending upon the size of the corn tassel. Early in the morning the bag is put over the tassel and tied or pinned around the stalk below. The anthers open soon after the sun begins to shine on the plants, and from 10:00 o'clock until noon is a good time to do the pollenizing. Pollen is shed most freely on warm, clear days.

The method here described has a number of distinct advantages when used with corn. The envelopes are easily made; after a little practice one person can make 25 or 30 in an hour. The worker is independent of the whim of any manufacturer, paper, twine, and paper clips being the only manufactured things that are necessary. The device is easily applied and easily manipulated; while the bag of pollen is held with one hand, the clip can be removed and the envelope opened with the other. The chance for contamination by stray pollen grains is minimized, for the envelope is never removed after being put in place, the silks are never touched by the hands, and the opening of the envelope exposes only a small surface for a short time. No umbrella or other protecting device is needed. The cover is well ventilated through the cotton, and the silks are protected from extremes of temperature, desiccation, or humidity. Well-filled ears have often resulted from a single pollination, and no failures have occurred which could be attributed to the lack of efficiency of the device.

While this method has been used chiefly with corn, it is capable of adaptation to other plants. The envelopes may be made in any size. When used over bisexual inflorescences to insure self-pollination, the envelope can be permanently closed at the top. A support can be provided when the plant is too small to hold the weight of an envelope large enough to cover its inflorescence.

A COMPARISON OF THE PLANT SUCCESSION ON HUDSON RIVER LIMESTONE WITH THAT ON NIAGARA LIMESTONE, NEAR RICHMOND, INDIANA.

M. S. MARKLE, Earlham College.

The outcrops of bed-rock in the vicinity of Richmond, Ind., consist of two kinds of rock, namely, Niagara limestone and Hudson River limestone. The marked differences between these two kinds of rock make a study of the plant succession on the outcrops very interesting.

The principal outcrop of the Hudson River limestone is in the gorge of the Whitewater River, where it passes through the city of Richmond. This gorge is about three miles long, 200-300 feet wide and up to 100 feet or more in depth. This gorge is supposed to have been formed immedi ately after the ice age.

Outcrops of Niagara limestone occur only south of the city, the principal ones being in the gorges below the falls at Elliott's Mills and at Elkhorn Mills, two and three miles southeast of Richmond, respectively. The present report is the result of a study of the outcrops in the Whitewater gorge and the gorge at Elkhorn Mills.

The principal differences between the two kinds of rocks is in their physical character. The Hudson River limestone is composed of alternate layers of calcareous shale and rather soft limestone. These constituents vary greatly in amount, the rock consisting in some places almost entirely of shale and in others almost entirely of limestone. Generally, however, they are about equal in amount. The Niagara limestone is not accompanied by shale, but consists entirely of hard thick-bedded limestone.

On account of the physical character of the Hudson River limestone, the plant succession in the Whitewater Gorge is very rapid for a rock cliff. The stage of the succession of any part of the cliff is due to the length of time that has elapsed since the cessation of active undercutting by the river. All stages of succession from the plantless rock to the climax mesophytic forest are to be found. The earliest stage in the succession occurs where the cliff is being actively eroded by the river.

The walls are almost vertical. No plants exist, except those hanging from the top of the cliff. In most successions on bare rock, lichens are the pioneer plants, being found in the most xerophytic situations. No lichens are found anywhere on the Hudson River limestone, on account, no doubt, of the unstable nature of the substratum. This plantless stage persists until after active undercutting by the stream has ceased.

Then the cliff becomes less steep. The talus accumulates undisturbed by the stream, and bears a considerable vegetation. In this stage occur the pioneer cliff plants, occupying the shelves formed by projecting layers of limestone. The most of the plants are annuals and many of them are plants that have slipped down from the top of the cliff. The following plants are common in this pioneer association: Ambrosia artemisiaefolia, Poa compressa, Lactuca scariola, Nepeta cataria, Melilotus alba, Dipsacus sylvestris, Aster spp.

The shale layers of the cliff change readily to soil, which is washed down by rains. Layers of limestone thus left projecting break off of their own weight and fall. With the consequent reduction in slope, an increasingly larger number of plants gain a foothold. In addition to some of the pioneer plants mentioned above occur the following: Equisetum arvense, Aster nova-angliae, Daucus carota, Heracleum lanatum, Melilotus officinalis, Verbascum thapsus, Elymus canadensis, Cornus paniculata.

Up to this point, the succession has been controlled almost entirely by physiogenic factors. The stage in succession depends upon the slope of the cliff. When, however, the slope has become sufficiently gentle to permit the accumulation of a layer of soil, biogenic factors, those due to other organisms, come in. The plants, particularly the grasses, hold the soil and retard the further degradation of the cliff. The slope of a portion of the cliff occupied by a mesophytic forest is about the same as that of a portion occupied by the bush stage. Each plant association prepares the way for the succeeding one by holding the soil, accumulating humus and providing shade.

The herbs are soon partially displaced by a bush association. The most common species is Rhus aromatica, which often forms large colonies. Cornus paniculata, Salix longifolia, Rhus toxicodendron, Vitus vulpina, crataegus, Psedera, Ptelea trifoliata Rubus, Ribes and others are accompanying species.

The shrub stage is succeeded by a xerophytic tree stage, corresponding probably to the usual oak-hickory stage. Ulmus americana is the pioneer tree. With it occur Celtis occidentalis, Crataegus, Robinia pseudo-acacia, Cercis canadenses, Prunus americana, Gleditschia triacanthos, Juglans nigra and Sambucus canadensis.

The pioneer tree association gradually merges into the ultimate stage of the region, the mesophytic forest. Mesophytism is indicated by the following species: Fagus grandifolia, Acer saccharum, Coprinus caroliniana, Ostrya virginica, Asimina triloba, Impatiens pallida, I. biflora, Viola cucullata, Galium spp.

For a more complete account of the succession in the Whitewater Gorge, see a paper by the writer in the proceedings of the Indiana Acadmy of Science for 1910.

The rock exposed in the gorge at Elkhorn Falls is Niagara limestone. The falls are occasioned by the presence underneath the hard Niagara limestone of a softer layer, which is probably Hudson River limestone. Below the falls is a gorge about one-half mile in length and 150 to 350 feet in width. On the walls of this gorge, various stages in plant succession may be observed.

In general, the earliest stages in the succession are to be found nearest the falls, though they may be found wherever a rejuvenescence of the succession has occurred. The pioneer association consists almost entirely of lichens, a large, gray, leathery species of Umbillicaria being the most prominent. This lichen covers the rock in all exposed situations, sometimes growing to a diameter of three inches.

The lichen association is followed by another, made up of a small black moss, probably a species of Grimmia, and such seed plants as Poa compressa, Nepeta cataria, Verbascum thapsus, Aster and Solidago.

These are succeeded, after further weathering of the rock and the accumulation of humus in the widening cracks, by an association dominated by Hydrangea arborescens and Aquilegia canadensis. These may be accompanied by Psedera quinquefolia.

The falls overhang a distance of 10 to 20 feet, on account of the weathering away of the softer lower stratum. For the same reason, the cliff soon becomes overhanging. This condition is more marked where stream action is prominent. Under these overhanging cliffs a very mesophytic association develops. Here occur Conocephalus, Cystopteris bul-

bifera, Camptosorus rhizophyllus, Pilea pumila, Aquilegia canadensis and Hydrangea arborescens. Psedera quinquefolia hangs in long streamers from the top of the cliff. On the edge of the cliff or on the talus beneath, where stream action is absent, occur Ulmus americana, Ostrya virginica, Prunus serotina, Celastrus scandens and Vitis. Under the cliff flourish such herbaceous plants as Sedum ternatum, Pilea pumila, Impatiens, Equisetum arvense, Eupatorium perfoliatum, Ambrosia trifida, Stellaria media, Galium, Carex and various mesophytic mosses. The mesophytic condition is due largely to the constant shade.

The vegetation becomes more and more mesophytic as the cliff becomes more overhanging. On account of the stability of the limestone, this may continue until the cliff overhangs to a surprising extent, but eventually overhanging portions of the cliff fall in large masses. This process is aided by the presence of prominent cleavage planes in two series at right angles to one another, but neither parallel to the edge of the cliff. The breaking off of the large masses gives the cliff a jagged appearance. The immediate result of the breaking off of a portion of the cliff is a rejuvenation of the succession. The mesophytic vegetation beneath the overhanging cliff is destroyed, both by being covered by the fallen fragments and by exposure. Stream action on the base of the cliff is hindered or rendered impossible by the covering of the soft underlying stratum. The stream is too weak to remove or wear away the fallen fragments. The fallen portions of the cliff eventually become covered with vegetation. The new, vertical faces of the cliff after a longer period are clothed with plants. Soil and humus accumulate more readily than before the interstices of the fragments, giving better conditions for the growth of trees. With the increase of shade, more mesophytic conditions prevail.

Slowly the edge of the cliff and the fallen masses of rock are crumbled by action of the weather. The result is finally a gentle slope with occasional remnants of the cliff projecting through the soil. The climax mesophytic forest does not occur here, though conditions approaching it are found at the lower end of the gorge. Tilia americana, Robinia pseudo-acacia, Morius rubra and Fraxinus americana are the principal trees, with an undergrowth of Sambucus canadensis and such herbs as Galium, Poa pratense, and Sedum ternatum.

On the whole, it would be difficult to find two rock-cliff successions

more different than the two just described. The differences become more striking when it is considered that the two successions are both on limestone, in the same region and on cliffs extending in the same general direction. The principal differences are as follows: (1) The succession on Hudson River limestone is more rapid than that on Niagara limestone. (2) There is a striking contrast in the pioneer stages. The pioneer association on Hudson River limestone is characterized by the complete absence of lichens, liverworts, xerophytic mosses and ferns, all of which are prominent on Niagara limestone. (3) In the Whitewater Gorge, the degradation of the cliffs of Hudson River limestone is accomplished by the crumbling of the rock into small fragments, while at Elkhorn Falls the fragments of Niagara limestone are of many tons' weight. (4) On account of the overhanging character of the cliff at Elkhorn Falls, an intermediate mesophytic stage is introduced into the succession.

Notes on Microscopic Technique.

M. S. Markle, Earlham College.

During the past few years I have been using very successfully a method of staining a number of slides at one time, a description of which may be of interest to others who have occasion to prepare large numbers of slides for class use or for research. The principal features of the method were suggested to me by Miss Louise Sawyer of the Department of Biology of Beloit College.

As shown in the illustration, the slides are held between the soils of a brass spring about an inch in diameter, made of No. 13 wire and wound with the coils in contact. By holding the spring in the left hand and forcing the first two coils apart with the thumb nail, the first slide may be inserted. After this, pressure applied by the thumb upon the slide just inserted separated the coils for the reception of the next slide.

As staining jars, I am now using Bausch and Lomb preservation jars No. 15166 holding 600 c.c., but Stender dishes about 100 mm. deep might prove to be more satisfactory. Vessels to contain stains in which the slides rest for a time (such as safrannin) are more economical of stain if larger.

A coil long enough to hold 12 to 15 slides has been found to be most satisfactory. The spring is kept uppermost until the final xylol is reached, when the spring is reversed, allowing the slides to be pulled out one at a time for mounting. It is easy to hold the rest of the slides with one hand while removing a slide with the other.

The spring I am using was made by Orr and Lockitt, Chicago; a spring about 18 inches long cost 65 cents at that time. Any hardware dealer ought to be able to obtain such a spring.

I have found it desirable to use 3 jars of 95 per cent. alcohol as well as 3 jars of xylol in the series of reagents through which the slides are run. As the alcohol becomes loaded with stain or water, the lowest grade is discarded, each of the others is reduced one grade and the third jar refilled with pure alcohol. The same scheme is used for xylol. By this means, one always has one vessel of pure reagent. Economy of reagents and efficiency of work are facilitated.

Balsam may be kept from spreading beyond the cover-glass and leaving a halo on the finished slide by wiping off the slide with an absorbent cloth close to the sections before putting on the cover-glass. The balsam will then spread to the edge of the cover-glass and stop.

A small amount of valuable material may be made to serve for a larger number of slides, smaller covers may be used, sections may be better oriented and worthless sections discarded if sections are examined just after the paraffin ribbons are stretched. Desirable sections may be cut out by rocking a round-edged scalpel. By laying a new slide smeared with fixative on the table in close contact with the original slide, the sections may be transferred to the new slide with the point of a scalpel, after adding a few drops of water to facilitate the moving of the sections. The sections may be more easily examined while in the paraffin if a little Magdala red is added to one of the higher alcohols in which the material is dehydrated previous to imbedding. The small amount of stain absorbed will not affect future staining operations.

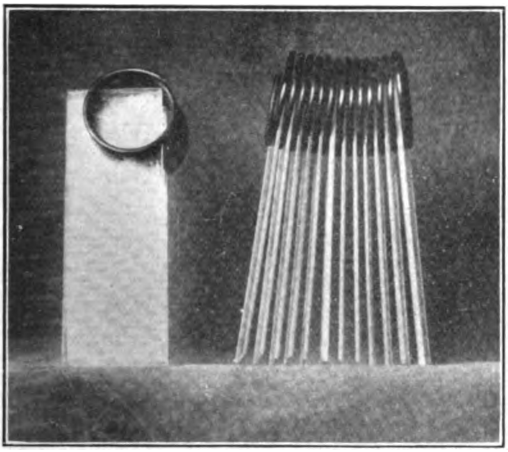
Female gametophytes in pine ovules usually shrink greatly when fixed and imbedded. This may be almost entirely obviated by cutting a slab off each side of the ovule before it is fixed. A Gillette razor blade is very satisfactory, since on account of its thinness it does not crush the material.

Seeds of the pinyon pine (Pinus edulis) are very satisfactory to illustrate the gross anatomy of the gymnosperm seed, since they are very large and easily dissected. The gametophyte and contained embryos or the embryos alone may be dissected out, soaked in water a short time, fixed and imbedded. They cut very easily.

A modification of Land's Fixative (See Botanical Gazette, Vol. LIX, page 397), has been used very successfully for refractory sections that will not adhere readily with egg albumen. Land's fixative dries very quickly, causing the liquid added to float the sections to spread with difficulty. By using the following formula, the liquid spreads as easily as with egg albumen:

2% gum arabic in water	50 c. c.
Glycerin	50 c. c.
Sodium salicylate	1 gram.

Use as egg albumen. Float sections on water slightly yellow with potassium dichromate. Stretch over warm plate. Melting the paraffin does not impair the efficiency of the fixative. When aqueous stains are used, no previous treatment is necessary; but when alcoholic stains only are to be used, it is best to set the slides for a short time in water to dissolve the excess of fixative adhering to the slide. Otherwise this precipitate will take the stain and spoil the appearance of the slide.



Method of holding microscopic slides in brass springs for staining.

This is best done before the paraffin is removed from the slides. The slides should be re-dried.

A hot-plate for stretching paraffin ribbons that is a great improvement over the old copper plate and gas flame may be made by putting an incandescent lamp in a box and making a glass lid. The heat is uniform. The glass plate gives better contact, though it is better to fill the space between the slide and the glass lid by putting a drop of water on the lid before placing the slide on it. A small box may be made of an ordinary chalk box, the sliding lid of which is replaced by a discarded photographic plate or other piece of glass. It is easier to remove the slides, however, if the lid is flush with the sides of the box.

THE USTILAGINALES OF INDIANA.[1]

H. S. JACKSON—Purdue University.

The following list of the Ustilaginales or "smuts" of Indiana is based primarily on the material in the writer's herbarium and in that of the Purdue University Agricultural Experiment Station. All of the Indiana material in the herbarium of the New York Botanical Garden has also been included, most of the specimens deposited there being collections made in Indiana by Dr. L. M. Underwood during the period when he was connected with DePauw University. The only previous lists of the smuts of Indiana were included in the List of Cryptogams prepared by Dr. Underwood, which appeared in the Proceedings of the Indiana Academy for 1893, and in the Supplementary list of 1894. A total of sixteen species were recorded. A few other scattered records appear in the literature, several having been made in the various lists of the Fungi of Indiana, by Prof. J. M. VanHook, which have been published in the Proceedings at various times. No attempt has been made to include all the localities recorded for the more common species. In general only those specimens are listed which the writer has had an opportunity to examine. Several species are included, however, which are based on the distribution records in the monograph of the Ustilaginales by Dr. G. P. Clinton, published in the North American Flora Vol. 7, pt. 1, 1906.

The present list includes a total of forty-seven species cn as many hosts. A large number of other species undoubtedly occur in our range. The writer would greatly appreciate it if collectors would furnish duplicates of specimens not recorded here, or which they may collect in the future, for use in preparing a supplementary list.

Acknowledgment is gratefully made to all those who have furnished specimens for study or who have assisted in any way in the preparation of the list.

[1] Contribution from the Botanical Department of the Purdue University Agricultural Experiment Station.

USTILAGINACEAE.

1. Cintractia Caricis (Pers.) Magn. Abh. Bot. Ver. Prov. Brand. 37:79. 1896.

Uredo Caricis Pers. Syn. Fung. 225. 1801.

ON CYPERACEAE:

Carex umbellata Schk., beech woods, ½ mile S. W. Chestnut Ridge, May 11, 1913, C. C. Deam 127116.

This species has a wide distribution in America as well as in other parts of the world where Carex species are native. It should be found on other host species in Indiana. The sori occur in the ovaries and when mature are rather conspicuous subspherical bodies 3-4 mm. in diameter.

2. CINTRACTIA JUNCI (Schw.) Trel. Bull. Torrey Club 12:70. 1885.

Caeoma Junci Schw. Trans. Am. Phil. Soc. II. 4:290. 1832.

ON JUNCACEAE:

Juncus diffusissimus Buckley, Versailles, Ripley County, June 18, 1915, C. C. Deam 16087.

Juncus tenuis Willd., Reynolds, White County, August 2, 1916, G. A. Osner.

3. CINTRACTIA LUZULAE (Sacc.) Clinton, Jour. Myc. 8:143. 1902.

Ustilago Luzulae Sacc. Myc. Ven. Spec. 73. 1873.

ON JUNCACEAE:

Juncoides campestre (L.) Kuntze, Greensburg, Decatur County, May 10, 1889, J. C. Arthur; Terre Haute, Vigo County, May 12, 1917, C. C. Deam 22959; Kramer, Warren County, May 18, 1917, C. C. Deam 23104; Salem, Washington County, C. C. Deam 23194.

Previously known from North America only from the one collection made in 1889 by Dr. Arthur at Greensburg, Ind. The sori are in the ovaries but are inconspicuous and hence easily overlooked. The species is doubtless of much wider distribution in this State than the above collections would indicate.

4. CINTRACTIA MONTAGNEI (Tul.) Magn. Abh. Bot. Ver. Prov. Brand. 37:79. 1896.

Ustilago Montagnei Tul. Ann. Sci. Nat. III. 7:88. 1847.

ON CYPERACEAE:

Rynchospora glomerata (L.) Vahl., Michigan City, Laporte County, September 13, 1916, H. S. Jackson and E. B. Mains.

5. MELANOPSICHIUM AUSTRO-AMERICANUM (Speg.) G. Beck, Ann. Nat. Hofmus. Wien 9:122. 1894.

Ustilago austro-americana Speg. Anal. Soc. Ci. Argent. 12:63. 1881.

ON POLYGONACEAE:

Persicaria pennsylvanica (L.) Small, Plymouth, Marshall County, September 5, 1916, H. S. Jackson.

A species causing conspicuous hard black sori in the infloresence.

6. SCHIZONELLA MELANOGRAMMA (DC.) Schröt. Beitr. Biol. Pfl. 2:352 1877.

Uredo melanogramma DC. Fl. Fr. 6:75. 1815.

ON CYPERACEAE:

Carex pennsylvanica Lam., Shades, Montgomery County, May 16, 1913, F. D. Kern; Happy Hollow, Lafayette, Tippecanoe County, May 3, 1906, G. W. Wilson 5485; Battle Ground, Tippecanoe County, June 18, 1916, Evelyn Allison; Rochester, Fulton County, May, 1894, L. M. Underwood, Ind. Biol. Sur. 10, May 17, 1894, J. C. Arthur; Pine Creek, Warren County, May 5, 1917, G. N. Hoffer.

Carex picta Steud., Bloomington, Monroe County, May 25, 1917, J. M. VanHook 3746, June 9, 1917, C. C. Deam 23569; Brown County, June 16, 1912, C. C. Deam.

A very common species, occurring on the leaves, forming epiphyllous linear black sori, which superficially resemble those of a rust.

7. SOROSPORIUM CONFUSUM Jackson Bull. Torrey Club 35:148. 1908.

ON POACEAE:

Aristida sp., Elberfeld, Warrick County, October 4, 1916, H. S. Jackson.

An inconspicuous species the sori of which occur in the ovaries, which remain enclosed in the glumes. This species was formerly confused with *S. Ellisii*, which is now interpreted as occurring only on Andropogon.

8. SOROSPORIUM SYNTHERISMAE (Peck) Farl.; Farl. & Seym. Host Index N. Am. Fungi 152. 1891.

Ustilago Syntherismae Peck, Ann. Rep. N. Y. State Mus. 27:103. 1875.

ON POACEAE:

Cenchrus carolinianus Walt., Michigan City, Laporte County, September 13, 1916, H. S. Jackson and E. B. Mains, Greencastle, Putnam County, October, 1892, L. M. Underwood, Ind. Biol. Sur. 6; Dayton, Tippecanoe County, November, 1917, H. S. Jackson.

Panicum dichotomiflorum Michx., Muncie, Delaware County, September 29, 1915, H. S. Jackson; Hammond, Lake County, October 14, 1914, F. J. Pipal.

The sori of this species as a rule cause the abortion of the entire infloresence.

9. SPHACELOTHECA SORGHI (Link) Clinton, Jour. Myc. 8:140. 1902.

SPORISORIUM SORGHI Link, in Willd. Sp. Pl. 6^2:86. 1825.

ON POACEAE:

Sorghum vulgare Pers. Muncie, Delaware County, September 29, 1915, H. S. Jackson; West Lafayette, Tippecanoe County, September 18, 1912, E. J. Petry, September 20, 1917, G. A. Osner, September, 1915, H. S. Jackson.

This, the kernel smut of sorghum, is evidently quite common. The head smut *S. Reilana*, which generally involves the whole inflorescence, has not yet been collected in Indiana.

10. USTILAGO ANOMALA J. Kunze, Wint. in Rab. Krypt. Fl. 1^1:100. 1881.

ON POLYGONACEAE:

Tiniaria scandens (L.) Small, Fern, Putnam County, September, 1893, L. M. Underwood, Ind. Biol. Sur. 1; Crawfordsville, Montgomery County, September 20, 1908, V. B. Stewart 8.

11. USTILAGO AVENAE (Pers.) Jens. Charb. Céréales 4:1889.

Uredo segetum Avenae Pers. Tent. Disp. Fung. 57. 1897.

ON POACEAE:

Avena sativa L., Greencastle, Putnam County, June 1893, L. M. Underwood; Lafayette, Tippecanoe County, 1893; J. C. Arthur (Und. Ind. Biol. Surv. 2); West Lafayette, Tippecanoe County, June 10, 1908, F. D. Kern, June 25, 1916, J. C. Summers; Holman, Dearborn County,

1889 (?), H. L. Bolley; Crawfordsville, Montgomery County, June 1892, E. W. Olive; Plymouth, Marshall County, June 29, 1916, G. A. Osner; Surrey, Jasper County, July 10, 1917, Chas. Chupp; South Bend, St. Joseph County, October 28, 1916, M. C. Gillis; Oaktown, Sullivan County, June 25, 1916, J. C. Summers; Lebanon, Boone County, July 17, 1916, P. S. Lowe; Griffiths, Lake County, July 27, 1916, G. A. Osner.

12. USTILAGO CALAMAGROSTIDIS (Fuckel) Clinton, Jour. Myc. 8:138. 1902.

Tilletia Calamagrostis Fuckel, Symb. Myc. 40. 1869.

ON POACEAE:

Calamagrostis canadensis (Michx.) Beauv., Plymouth, Marshall County, June 21, 1916, G. A. Osner.

Evidently a rather rare species, but having a wide distribution. The sori occur on the leaves and sheaths and in general features the species resembles *U. Striaeformis*.

13. USTILAGO CRAMERI Körn.; Fuckel, Jahr. Nass. Ver. Nat. 27-28:11. 1873.

ON POACEAE:

Chaetochloa italica (L.) Scribn., West Lafayette, Tippecanoe County, September 14, 1915, H. S. Jackson.

14. USTILAGO HORDEI (Pers.) Kellerm. & Swingle, Ann. Rep. Kans. Agr. Exp. Sta. 2:268. 1890.

Uredo segetum Hordei Pers. Tent. Disp. Fung. 57. 1797.

ON POACEAE:

Hordeum vulgare L., Lafayette, Tippecanoe County, July 2, 1891, J. C. Arthur; Auburn, Dekalb County, July 19, 1917, F. J. Pipal.

This is the so-called covered smut of barley. It is undoubtedly much more common than the above listed collections would indicate.

15. USTILAGO LEVIS (Kell. & Sw.) Magn. Abh. Bot. Ver. Prov. Brand. 37:69. 1896.

Ustilago Avenae levis Kell. & Sw. Ann. Rep. Kans. Agr. Exp. Sta. 2:259. 1890.

ON POACEAE:

Avena sativa L., Lafayette, Tippecanoe County, June 1890, J. C. Arthur, June 26, 1915, C. A. Ludwig (Barth. Fungi Columb. 4795);

Griffiths, Lake County, July 27, 1916, G. A. Osner; Greencastle, Putnam County, June 1893, L. M. Underwood; Lebanon, Boone County, July 25, 1916, P. S. Lowe; North Liberty, St. Joseph County, August 9, 1916, G. A. Osner.

16. USTILAGO NEGLECTA Niessl, Rab. Fungi Eur. 1200. 1868.

Erysibe Panicorum Panici-glauci Wallr. Fl. Crypt. Germ. 2:216. 1833.

Ustilago Panici-glauci Wint.; Rab. Krypt. Fl. 1[1]:97. 1881.

ON POACEAE:

Chaetochloa glauca (L.) Scribn., Lafayette, Tippecanoe County, 1893, J. C. Arthur (Und. Ind. Biol. Surv. 3); West Lafayette, Tippecanoe County, September 24, 1915, H. S. Jackson; Middletown, Henry County, September 30, 1915, H. S. Jackson; Argos, Marshall County, September 26, 1916, G. A. Osner.

17. USTILAGO NUDA (Jens.) Kell. & Sw. Ann. Rep. Kans. Agr. Exp. Sta. 2:277. 1890.

Ustilago Hordei nuda Jens. Charb. Céréales 4. 1889.

ON POACEAE:

Hordeum vulgare L., Manchester, Dearborn County, June 20, 1889, H. L. Bolley; Griffith, Lake County, July 27, 1916, G. A. Osner; Lafayette, Tippecanoe County, July 2, 1891, J. C. Arthur, June 22, 1917, H. S. Jackson; Fremont, Steuben County, June 27, 1910, O. S. Roberts; Auburn, Dekalb County, July 19, 1917, F. J. Pipal.

This, the loose smut of barley, is everywhere common and causes considerable loss each year. A collection made in the greenhouse showed infection on the sheaths and leaves as well as the infloresence.

18. USTILAGO PERENNANS Rostr. Overs. K. Danske Vid. Selsk. Forh. 1890:15. Mr. 1890.

Cintractia Avenae Ellis & Tracy, Jour. Myc. 6:77. S. 1890.

ON POACEAE:

Arrhenatherum elatius (L.) Beauv., Lafayette, Tippecanoe County, June 10, 1897, Wm. Stuart.

19. USTILAGO PUSTULATA Tracy & Earle, Bull. Torrey Club 22:175. 1895.

ON POACEAE:

Panicum dichotomiflorum Michx., Evansville, Vanderburgh County, October 4, 1916, H. S. Jackson.

20. Ustilago Rabenhorstiana Kühn. Hedwigia 15:4. 1876.

On Poaceae:

Syntherisma sanguinale (L.) Dulac., Greencastle, Putnam County, October 1892, L. M. Underwood, Ind. Biol. Surv. 5; Oakland City, Gibson County, October 5, 1916, H. S. Jackson; Michigan City, Laporte County, September 13, 1916, H. S. Jackson and E. B. Mains; Lafayette, Tippecanoe County, September 11, 1891, J. C. Arthur; West Lafayette, Tippecanoe County, September 3, 19, 1915, H. S. Jackson; Paoli, Orange County, September 27, 1915, H. S. Jackson; Marion, Grant County, October 11, 1915, F. J. Pipal; Plymouth, Marshall County, September 12, 27, 1916, G. A. Osner; Goshen, Elkhart Co., October 10, 1916, G. A. Osner; Evansville, Vanderburgh County, October 4, 1916, H. S. Jackson.

Perhaps the most common, at least the most frequently collected smut occurring on a native grass in our region. The entire infloresence is usually affected.

21. Ustilago spermophora B. & C. Sacc. Syll. Fung. 7^2:466. 1888.

On Poaceae:

Eragrostis major Host., Middletown, Henry County, September 30, 1915, H. S. Jackson.

An inconspicuous but probably not uncommon species.

22. Ustilago sphaerogena Burrill, Sacc. Syll. Fung. 7^2:468. 1888.

On Poaceae:

Echinochloa Crus-galli (L.) Beauv., Blooming Grove, Franklin County, September 7, 1913, C. A. Ludwig; Lafayette, Tippecanoe County, October 5, 1909, A. G. Johnson, October 1, 1916, H. S. Jackson.

23. Ustilago Tritici (Pers.) Rostr. Overs. K. Danske Vid. Selsk. Forh. **1890**:15. Mr. 1890.

Uredo segetum Tritici Pers. Tent. Disp. Fung. 57. 1797.

On Poaceae:

Triticum vulgare (collective), Lafayette, Tippecanoe County, 1893, J. C. Arthur (Und. Ind. Biol. Surv. 4), June 20, 1916, H. S. Jackson; Greencastle, Putnam County, June 1893, L. M. Underwood; Brown County, May 1893, L. M. Underwood; Crawfordsville, Montgomery County, June 1892, M. B. Thomas; Wabash County, June 20, 1888, A. Miller 18; Plymouth, Marshall County, June 29, 1916, G. A. Osner; Petersburg, Pike Co., October 18, 1910, Blake A. Lamb; Mt. Vernon,

Posey County, May 14, 1910, A. G. Johnson; Franklin County, July 1, 1912, C. A. Ludwig; Claypool, Kosciusko County, June 11, 1916, R. C. Hathaway.

The loose smut of wheat is undoubtedly present in all counties of the State and is estimated to cause a reduction in yield of 3-4 per cent for the State. This means that from one to one and one-quarter million bushels are lost annually from this disease.

24. USTILAGO STRIAEFORMIS (Westend.) Niessl, Hedwigia 15:1. 1876.

Uredo striaeformis Westend. Bull. Acad. Roy. Belg. 18^2:406. 1851.

ON POACEAE:

Agrostis alba vulgaris (With.) Thurb., Plymouth, Marshall County, June 22, 1916, G. A. Osner; Brazil, Clay County, June 22, 1917, G. A. Osner.

Phleum pratense L., Greencastle, Putnam County, May 1893, L. M. Underwood, Ind. Biol. Surv. 9; Plymouth, Marshall County, June 22, 1916, G. A. Osner; Lafayette, Tippecanoe County, June 24, 1898, Wm. Stuart; Monroeville, Morgan County, July 28, 1917, G. A. Osner.

Poa pratensis L., Plymouth, Marshall County, June 21, 29, 1916, G. A. Osner.

25. USTILAGO UTRICULOSA (Nees) Tul. Ann. Sci. Nat. III. 7:102. 1847.

Caeoma utriculosa Nees, Syst. Pilze 1:14. 1817.

ON POLYGONACEAE:

Persicaria amphibii (L.) S. F. Gray, Wabash County, October 16, 1890, A. Miller 10.

Persicaria pennsylvanica (L.) Small, Michigan City, Laporte County, September 13, 1916, H. S. Jackson and E. B. Mains; Lafayette, Tippecanoe County, October 3, 1915, H. S. Jackson; Muncie, Delaware County, September 29, 1915, H. S. Jackson; Plymouth, Marshall County, September 5, 1916, G. A. Osner, September 5, 1916, H. S. Jackson; Oakland City, Gibson County, October 5, 1916, H. S. Jackson.

26. USTILAGO VILFAE Wint. Bull. Torrey Club 10:7. 1883.

ON POACEAE:

Sporobolus neglectus Nash, West Lafayette, Tippecanoe County, October 23, 1912, E. J. Petry.

27. Ustilago Zeae (Beckm.) Unger, Einfl. Bodens 211. 1836.

Lycoperdon Zeae Beckm. Hannov. Mag. 6:1330. 1768.

Uredo Zeae Schw. Schr. Nat. Ges. Leipzig 1:71. 1822.

On Poaceae:

Euchlaena mexicana Schrad., Bloomington, Monroe County, Summer 1917, P. Weatherwax.

Zea Mays L., Greencastle, Putnam County, October 1893, L. M. Underwood, Ind. Biol. Surv. 7; Plymouth, Marshall County, September 5, 1916, H. S. Jackson; Lebanon, Boone County, August 1, 1916, P. S. Lowe; Grovertown, Starke County, August 22, 1917, C. R. Hoffer; Lafayette, Tippecanoe County, September 1, 1917, G. A. Osner.

The common corn smut is known in every county of the State. Only a few localities are listed, which include those from which specimens are preserved.

28. Ustilago sp.

On Poaceae:

Secale cereale L., Bainbridge, Putnam County, June 1917, G. A. Osner; Lafayette, Tippecanoe County, June 5, 1917, G. A. Osner; Surrey, Jasper County, July 10, 1917, Chas. Chupp.

A loose smut of rye, indistinguishable in its morphological characters from the loose smut of wheat, U. Tritici, has been found in three fields in Indiana. Usually only a portion of the florets are infected. The exact status of this smut must remain in doubt till infection work has been conducted.

TILLETIACEAE.

29. Doassansia deformans Setch. Proc. Am. Acad. 26:17. 1891.

On Alismaceae:

Sagittaria latifolia Willd., Michigan City, Laporte County, September 13, 1916, H. S. Jackson and E. B. Mains.

This species causes considerable distortion of the affected parts. The collection recorded above consisted in the main of a distorted flower stalk.

30. DOASSANSIA OPACA Setch. Proc. Am. Acad. **26**:15. 1891.

ON ALISMACEAE:

Sagittaria latifolia Willd., Winona Lake, Kosciusko County, August 31, 1916, H. S. Jackson and G. N. Hoffer.

This species forms opaque spore balls in the mesophyll of the leaf causing considerable thickening.

31. ENTYLOMA AUSTRALE Speg. Anal. Soc. Ci. Argent. **10**:5. 1880.

ON SOLANACEAE:

Physalis pubescens L., Greencastle, Putnam County, October 1893, L. M. Underwood, Ind. Biol. Surv. 8.

Physalis subglabrata Mackensie and Bush, Urmeyville, Johnson County, November 1890, E. M. Fisher 816.

32. ENTYLOMA CRASTOPHILUM Sacc. Michelia **1**:540. 1879.

ON POACEAE:

Muhlenbergia mexicana (L.) Trin., Lafayette, Tippecanoe County, November 11, 1916, E. B. Mains.

This collection is referred to this species somewhat doubtfully. We have seen no other record of a species of Entyloma on this host species.

33. ENTYLOMA COMPOSITARUM Farl. Bot. Gaz. **8**:275. 1883.

ON AMBROSIACEAE:

Ambrosia elatior L. (*A. artemisiaefolia* L.), Lafayette, Tippecanoe County, July 2, 1889, J. C. Arthur.

ON CARDUACEAE:

Senecio aureus L., Lafayette, Tippecanoe County, May 22, 1916, H. S. Jackson.

34. ENTYLOMA FLOERKEAE Holway; Davis, Trans. Wisc. Acad. **11**:170. 1897.

ON LIMNANTHACEAE:

Floerkea proserpinacoides Willd., Lafayette, Tippecanoe County, May 8, 1898, J. C. Arthur.

A rather rare species reported otherwise only from Illinois, Ohio and Wisconsin. The writer has also collected it in Delaware.

35. ENTYLOMA LOBELIAE Farl. Bot. Gaz. **8**:275. 1883.

ON LOBELIACEAE:

Lobelia inflata L., Bloomington, Monroe County, Campus Indiana Univ., October 26, 1915, J. M. VanHook 3664.

36. Entyloma microsporum (Ung.) Schröt.; Rab. Fungi Eur. 1872. 1874.

Protomyces microsporus Ung., Exanth. Pfl. 343. 1833.

On Ranunculaceae:

Ranunculus septentrionalis Poir, Lafayette, Tippecanoe County, May 17, 1883, J. C. Arthur, May 29, 1894, K. E. Golden, May 1, 1906, G. W. Wilson 5473, October 29, 1916, H. S. Jackson.

37. Entyloma polysporum (Peck) Farl. Bot. Gaz. 8:275. 1883.

Protomyces polysporus Peck; Thüm. Myc. Univ. 1813. 1881.

On Ambrosiaceae:

Ambrosia elatior L. (*A. artemisaefolia* L.).

Reported on the above host from Indiana by Clinton (N. A. Flora 7:62. 1906). We have not seen specimens.

38. Entyloma Saniculae Peck, Ann. Rep. N. Y. State Mus. 38:100. 1885.

On Ammiaceae:

Sanicula sp., Greencastle, Putnam County, May 1893, L. M. Underwood.

39. Entyloma speciosum Schröt. & P. Henn. Hedwigia 35:220. 1896.

On Poaceae:

Panicum dichtomiflorum Michx., Evansville, Vanderburgh County, October 4, 1916, H. S. Jackson.

Otherwise reported on this host (as *P. proliferum*) from North America only from Illinois. The specimen recorded above was obtained from the same plants on which *Ustilago pustulata* was collected.

40. Entyloma Veronicae (Wint.) Lagerh., Pat. & Lagerh. Bull. Soc. Myc. Fr. 7:170. 1891.

Entyloma Linariae Veronicae Wint.; Rab.-Wint. Fungi Eur. 3001. 1884.

On Scropulariaceae:

Veronica perigrina L., Lafayette, Tippecanoe County, April 18, 1916, May 6, 19, 1916, H. S. Jackson; Mt. Vernon, Posey County, May 11, 1916, H. S. Jackson.

A very common species in the vicinity of Lafayette, causing yellowish or whitish well defined spots on the leaves.

41. TILLETIA LAEVIS Kühn; Rab. Fungi Eur. 1697. 1873.

Ustilago foetens B. & C. Grevillea, 3:59. 1874.

ON POACEAE:

Triticum vulgare (collective), Haw Patch, July 17, 1889; Jonesboro, Grant County, July 30, 1910, Neill and VanHook; Fort Wayne, Allen County, July 21, 1910, O. S. Roberts; Franklin, Johnson County, July 5, 1909, Comm. E. A. Feight; New Carlisle, St. Joseph County, July 10, 1917, G. A. Osner.

This, the "stinking smut" or "bunt" of wheat, is much more widespread in the State than the above distribution would indicate.

42. TILLETIA TRITICI (Bjerk.) Wint. Rab. Krypt. Fl. 1^1:110. 1881.

Lycoperdon Tritici Bjerk. K. Sv. Vet.-Acad. Handl. **36**:326. 1775.

ON POACEAE:

Triticum vulgare L., New Carlisle, St. Joseph County, July 10, 1917, G. A. Osner.

This specimen consists of a single head found mixed with the preceding species. This species undoubtedly occurs not infrequently in the northern part of the State. It is not to be expected that it is as common as *T. laevis* however.

The report of the occurrence in Indiana of *T. Tritici* made in the Proceedings for 1915 (p. 396) has been found to have been based on an error in determination.

43. UROCYSTIS AGROPYRI (Preuss) Schröt. Abh. Schles. Ges. Abth. Nat. Med. 1869-72:7. 1870.

Uredo Agropyri Preuss, in Sturm, Deutsh. Fl. III. 25:1. 1848.

ON POACEAE:

Agropyron repens (L.) Beauv., West Lafayette, Tippecanoe County, May 30, 1915, C. R. Orton and F. D. Fromme.

Elymus virginicus L., Lafayette, Tippecanoe County, July 22, 1917, E. B. Mains.

44. UROCYSTIS ANEMONES (Pers.) Wint.; Rab. Krypt. Fl. 1^1:123. 1881.

Uredo Anemones Pers. Tent. Disp. Fung. 56. 1797.

ON RANUNCULACEAE:

Anemone virginiana L., Lafayette, Tippecanoe County, April 24, 1906, G. W. Wilson.

Hepatica acutiloba DC., Lafayette, Tippecanoe County, May 29, 1893, J. C. Arthur, June 29, 1916, G. N. Hoffer.

45. UROCYSTIS CEPULAE Frost. Farl. Ann. Rep. Sec. Mass. Board Agr. 24. 175. 1877.

ON ALLIACEAE:

Allium cepa L.

Reported by Underwood (Proc. Ind. Acad. Sci. 1894:151. 1895), as occurring on onions in market, Putnam County, December 1893. Clinton (N. Am. Flora 7:57. 1906), also reports this from Indiana. A specimen in the N. Y. Botanical Garden, collected by Underwood in Indiana, is sterile. The species undoubtedly occurs in northern Indiana.

46. UROCYSTIS COLCHICI (Schlecht.) Rab. Fungi Eur. 396. 1861.

Caeoma Colchici Schlecht. Linnaea 1:241. 1826.

ON LILIACEAE:

Quamasia hyacinthina (Raf.) Britton, Lafayette, Tippecanoe County, May 30, 1907, F. Vasku, May 22, 1916, H. S. Jackson, May 1917, G. N. Hoffer.

These collections are referred here somewhat doubtfully. The writer is unaware of any record of the occurrence of Urocystis on this host genus though he has made similar collections in Oregon on a western member of the genus.

47. UROCYSTIS OCCULTA (Wallr.) Rab.; Klotzsch. Herb. Viv. Myc. II. 393. 1856.

Erysibe occulta Wallr. Fl. Crypt. Germ. 2:212. 1833.

ON POACEAE:

Secale cereale L., Plymouth, Marshall County, June 20, 1916, G. A. Osner; Avilla, Noble County, June 23, 1908, H. H. Whetzel; Lafayette, Tippecanoe County, June 1917, H. S. Jackson; Brainbridge, Putnam County, June 27, 1917, G. A. Osner.

The flag smut of rye is evidently not uncommon, but usually causes little damage.

HOST INDEX.

THE UREDINALES OF INDIANA II.[1]

H. S. JACKSON, Purdue University.

The following records of Indiana rusts are presented at this time as the first supplement to the article by the writer on "The Uredinales of Indiana," which was published in the Proceedings of the Academy for 1915. All the unrecorded species which have come to hand since the publication of that list are included, together with a few forms which for one reason or another were omitted at that time.

A large number of collections have been examined which add many new localities and a number of new hosts for previously recorded species. These are not included in the present list but will be recorded at another time. The previous list contained records of 141 species exclusive of unconnected species of Aecidium. The latter are included in the present list and taken together with other accessions brings the number of species known from the State to a total of 155.

In order to avoid making new combinations the older and more familiar nomenclature is used.

The writer is under great obligation to all those who have been kind enough to furnish specimens for study, especially to Dr. J. C. Arthur, Prof. G. N. Hoffer, Mr. C. C. Deam and Mr. J. B. Demaree, who have placed their collections at his disposal.

UREDINACEAE.

142. MELAMPSORA EUPHORBIAE-GERARDIANA W. Müller, Centr. Bakt. 17^2:210. 1906.

ON EUPHORBIACEAE:

Tithymalus commutatus (Engelm.) K. and Garcke, West of High Lake, Noble County, June 11, 1916, C. C. Deam 20083A; Wea Creek, S. W. Lafayette, Tippecanoe County, April 22, 1917, E. J. Petry.

The above are the only collections of this species from North America (Mains, Phytopath. 7:102. 1917).

[1] Contribution from the Botanical Department of the Purdue University Agricultural Experiment Station.

The second collection also bore some *Aecidium Tithymali.* Both species develop the sori on a diffused mycelium.

143. UREDINOPSIS ATKINSONII Magn. Hedwigia 43:123. 1904.

ON POLYPODIACEAE:

Dryopteris thelypetris (L.) A. Gray, Winona Lake, Kosciusko County, August 31, 1916, H. S. Jackson and G. N. Hoffer.

144. UREDINOPSIS MIRABILIS (Pk.) Magn. Hedwigia 43:121. 1904.

Septoria mirabilis Pk. Ann. Rep. N. Y. State Mus. 25:87. 1873.

ON POLYPODIACEAE:

Onoclea sensibilis L., Winona Lake, Kosciusko County, August 31, 1916, H. S. Jackson and G. N. Hoffer.

PUCCINIACEAE.

145. PUCCINIA ACETOSAE (Schum.) Körn. Hedwigia 15:184. 1876.

Uredo Acetosae Schum. Enum. Pl. Saell. 2:231. 1803.

ON POLYGONACEAE:

Rumex acetosella L., North Madison, Jefferson County, May 14, 1916, J. B. Demaree.

This is the first collection which we have seen of this species from any inland state. It is known otherwise only from Atlantic coast states and from near the Pacific coast in Oregon.

146. PUCCINIA LYSIMACHIATA (Lk.) Kern, Mycologia 9:215. 1917.

Aecidium Lysimachiae Schw. Schrift. Nat. Ges. Leipzig 1:67. 1822.

Puccinia Limosae Magn. Amtl. Ber. Vers. Deutsch. Naturf. u. Aerzte 1877:200. 1877.

ON PRIMULACEAE:

Naumbergia thyrsiflora (L.) Duby, Ligonier, Noble County, June 18, 1917, C. C. Deam 23665.

Aecia only have been collected in Indiana. Uredinia and telia are recorded from the eastern and middle western States on various species of Carex. No successful culture work has been conducted in America, the connection having been established by European authors.

147. Uromyces houstoniatus (Schw.) Sheldon, Torreya 9:55. 1909.
Caeoma (Aecidium) houstoniatum Schw. Trans. Am. Phil. Soc. II. 4:293. 1832.

On Rubiaceae:

Houstonia caerulea L., Bennettsville, Clarke County, May 30, 1917, C. C. Deam 23260.

This species has uredinia and telia on Sisyrinchium sp., culture work having been conducted first by Sheldon (l. c.) and later confirmed by Arthur (Mycol. 1:237. 1909). The telia have not yet been collected in Indiana.

148. Uromyces magnatus Arth. Mycologia 9:311. 1917.
Aecidium magnatum Arth. Bull. Torrey Club 28:664. 1901.

On Convallariaceae:

Polygonatum biflorum (Walt.) Ell., Ontario, Lagrange County, June 17, 1917, C. C. Deam 23642.

This aecidium has not before been reported from Indiana. It has recently been shown by Arthur (l. c.) to be connected with uredinia and telia on Spartina formerly included with *Uromyces acuminatus* Arth. (*Nigredo Polemonii* (Pk.) Arth.). The telia are indistinguishable from the collective species which has aecia also on various members of the Caryophyllaceae, Primulaceae and Polemoniaceae. This form is here listed under the distinctive name as the aeciospores are considerably larger than the forms on other aecial hosts belonging to the families mentioned above.

Telia have been collected in Indiana on *Spartina Michauxiana* and reported in previous lists under the collective name. Aecia are also known on *Polemonium reptans*.

149. Uromyces seditiosus Kern, Torreya 11:212. 1911.

On Poaceae:

Aristida ramosissima Engelm., Washington, Daviess Co., September 29, 1910, C. C. Deam 7618; Elberfeld, Warrick County, October 4, 1916, H. S. Jackson.

Aecia occur on various species of Plantago but have not yet been collected in Indiana.

UNCONNECTED FORMS.

150. AECIDIUM BOEHMERIAE Arth. Bull. Torrey Club 34:590. 1907.

ON URTICACEAE:

Boehmeria cylindrica (L.) Willd., Shades, Montgomery County, May 26, 1899, J. C. Arthur.

An unconnected Aecidium the relationship of which is uncertain. It has been collected otherwise only in Tacoma Park, District of Columbia.

151. AECIDIUM DICENTRAE Trel. Trans. Wis. Acad. Sci. 6:136. Nov. 1884.

ON FUMARIACEAE:

Bicuculla Cucullaria (L.) Millsp., Crawfordsville, Montgomery County, June 1893, E. W. Olive.

No clue to the relationship of this interesting aecidium is available.

152. AECIDIUM TITHYMALI Arth. Bull. Torrey Club 45:151. 1918.

ON EUPHORBIACEAE:

Tithymalus commutatus (Engelm.) Kl. & Garcke, Lafayette, Tippecanoe County, June 7, 1901, H. B. Dorner, 1905, G. W. Wilson, May 13, 1910, F. D. Kern and T. Billings, April 27, 1917, E. J. Petry; Crawfordsville, Montgomery County, May 17, 1913, F. D. Kern.

While many attempts have been made to culture this presumably heteroecious form, no success has been met with and its relationship is still in doubt. It has formerly been commonly reported as *A. Euphorbiae* Pers., now interpreted as a European species not occurring in America.

153. AECIDIUM HYDNOIDEUM B. & C. Grevillea 3:61. 1874.

ON THYMELIACEAE:

Dirca palustris L., Crawfordsville, Montgomery County, 1893, E. W. Olive; Everton, Fayette County, June 24, 1913, May 14, 1915, C. A. Ludwig (Barth. N. A. Ured. 901; Fungi Columb. 4501); West Lafayette, Tippecanoe County, June 5, 1911, G. N. Hoffer; Urmeyville, Johnson County, 1890, E. M. Fisher 929.

A very distinct and quite common heteroecious form which has not been successfully connected, though many attempts at culture have been made.

154. AECIDIUM PHYSALIDIS Burrill, Bot. Gaz. 9:190. 1884.

ON SOLANACEAE:

Physalis heterophylla Nees, Wea Creek, below Elston, Tippecanoe County, June 27, 1900, Wm. Stuart.

A distinct form developing from a diffused mycelium. Only pycnia are present in the specimen listed above though the species has frequently been observed in this locality. Another collection is reported by Underwood.

155. AECIDIUM TRILLII Burrill, Bot. Gaz. 9:190. 1884.

ON TRILLIACEAE:

Trillium sp., Lafayette, Tippecanoe County, June 1894, K. Golden.

Reported by Miss Lillian Snyder in the Proceedings for 1896, p. 218. No specimens have been seen. A rather rare species whose relationship is unknown.

A Suspected Case of Stock Poisoning by Wild Onion (Allium Canadense.)[1]

F. J. Pipal, Purdue University.

On June 23, 1917, a case of live-stock poisoning had been reported by Mr. William Feldt, living about five and one-half miles southeast of Lafayette. Dr. G. M. Funkhouser, of Lafayette, who investigated the case, reported, in substance, the following facts:

Five cows and one heifer were taken from a timothy pasture, which was rather dry and short at that time, and turned into a woods pasture on Sunday morning. In the evening of the same day, only four cows and the heifer returned from the pasture to the farm barnyard. The fifth cow was found in the pasture lying down and unable to get up. When the cows were milked it was noticed, with one exception, that the milk emitted a very strong and offensive odor and had considerably decreased in quantity. The breath of the cows was also strongly tainted with this odor and, in fact, it seemed that their whole bodies exhaled it.

On the following morning the doctor found the cow left in the pasture in a complete paralytic condition, her temperature, however, being quite normal; she died two days later. One of the cows in the barnyard was, by this time, in a similar condition and died the same day. One of the remaining three cows stood with her head erect, the hair bristling, and refused to move. Another had a tendency to draw her head to one side and when compelled to move went around in a circle and fell down. The third had a staring attitude and also a tendency to move in a circle. The temperature of all three animals was normal. All died on the following day. The heifer also had a staring attitude and in addition showed signs of cerebral disturbance, acting rather wildly.

The post-mortem examination showed that the inside membrane of the paunch was strongly affected, appearing as though scalded and

[1] Contribution from the Department of Botany of the Purdue University Agricultural Experiment Station.

sloughing off very readily. The feces of the affected animals were comparatively thin and very dark. The intestinal tract was inflamed and

Wild Onion (Allium canadense).

showed effects similar to those produced by gastro-enteritis. The contents of the paunch also emitted a very strong odor identical with that noted in the milk.

In treating the animals cathartics and stimulants were administered, but, as already stated, all cows died and only the heifer survived after a long struggle. It may be of interest to note that this heifer refused feed for several days after becoming poisoned; however, when a bunch of wild onions was offered to her, she displayed a greedy appetite for it and would have devoured it had she been permitted to do so.

The strong odor detected in the milk, breath and the paunch of the poisoned animals closely resembled that of wild onion and provided a clue for the probable cause of poisoning. In making a close search of the pasture in question a good-sized patch of wild onion (Allium canadense) was found. No other poisonous plants were noticed. The onion patch showed much evidence of recent grazing and it appeared quite certain that the cows had partaken of the onions. The plants in question were nearly mature, each having a cluster of a dozen or more aerial bulblets. The leaves were nearly all dried and the stems were rather tough. It was quite apparent, therefore, that the aerial bulblets formed the main portion of the cows' feast.

All evidence seemed to point to the onions as the cause of the poisoning. This particular species and its close relative, wild garlic (Allium vineale), are well known to taint dairy products and the flesh of animals feeding on them in the pastures of southern Indiana. In addition to the tainting effect, they may also produce colic and diarrhoea, especially in horses. No effects of more serious consequence, however, were ever recorded. All kinds of live-stock are fond of wild onions and garlic and will usually take them in preference to any forage plants. However, the plants are generally eaten, whenever found in the pastures, in their tender leaf stage early in the spring. The young plants are very mild in flavor as compared with the mature plants, especially the aerial bulblets. The oil which gives the plants their characteristic odor and which may seriously affect the grazing animals, is, undoubtedly, developed in greater proportion in the bulblets than in the foliage of the young plants. This may account for the fact that young plants cause no serious poisoning while plants with fully developed aerial bulblets are liable to prove of serious consequence when eaten in excessive quantities, especially if the stock is not accustomed to them. Two other heads of stock had been in the pasture in question throughout the spring months and no doubt pastured on the onions. Owing to the

reasons stated above, however, they did not seem to be troubled in any way. The poisoned animals were turned in from a pasture in which good feed was very scant and coming upon the onion patch, they undoubtedly gorged themselves with the succulent onion bulblets.

Literature on poisonous plants records no case of live-stock poisoning due to wild onion. The Lily family, to which wild onion belongs, contains several poisonous plants, the most dangerous of which are, perhaps, Death Camas and Colchicum, the latter species containing an alkaloid known as colchicin ($C_{22}H_{25}NO_6$). It is said[2] that "the animals which eat the plant (Colchicum) suffer with acute gastro-enteritis, coma, staggering, weak pulse and increased urination." Inasmuch as the cows in question showed some of these symptoms, particularly the first three, it appears probable that the onion bulblets contained some poisonous principles similar to those of Colchicum. Allium unifolium,[3] a close relative of Allium canadense, is said to be poisonous in California.

Pammel[4] mentions a report published by Dr. W. W. Goldsmith in the Journal of Comparative Pathology and Therapeutics, and later abstracted in the American Veterinary Review (36:63), by Prof. A. Liautard, upon cattle poisoning, caused by the garden onion. The following facts are submitted:

"Loads of onions partly started to shoot and partly decayed, were unloaded in a meadow where nine head of cattle were grazing. After a week the cattle seemed sick and one died, displaying the following symptoms: Intense onion odor; tucking up of flanks; constipation in some; purging freely in others; one vomited abundantly; another very ill, grunted, was much constipated, staggered in walking, was very tender in loins, temperature 103°, urine dark and smelling of onions. Treatment: Feeding with soft food and hay. Large doses of linseed oil. One animal that was very ill got also extract of belladonna and carbonate of soda. All but one of the animals recovered. At the autopsy of the dead one, the rumen was found inflated and also the bowels. Liver enlarged and of light color. Kidneys dark green and with offensive odor. Rumen contained large quantity of onions and grass. The whole carcass and organs smell of onions."

[2] Pammel: Manual of Poisonous Plants, Part II, Page 375.
[3] Pammel: Manual of Poisonous Plants, Part I, Page 104.
[4] Pammel: Manual of Poisonous Plants, Part II, Pages 383-384.

The oil which gives all species of the onion family their characteristic odor, consists of oxide and sulfides of allyl. According to the National Dispensatory, rectified oil contains mainly a sulfide compound $(C_3H_5)_2S$. This compound is said to possess a stimulating effect upon the organs of the digestive system. If taken in excessive quantities it produces nausea, vomiting, colic and diarrhoea. When in contact with the skin it reddens it and may even vesicate it. In mucous membranes this effect would no doubt be even more pronounced.

In summarizing the evidence pointing to wild onion as the probable cause of poisoning the cows in question, the following facts stand out prominently:

1. Apparently healthy cows were taken from a pasture where feed was scant and turned into a woods pasture where they found and grazed heavily on a patch of succulent wild onions.

2. Symptoms of poisoning appeared within twelve hours after pasture was changed.

3. The attending veterinary found no other cause, aside from forage poisoning, which might have been responsible for the condition of the affected cows.

4. The characteristic odor of wild onion was strongly pronounced in the milk and the whole system of the poisoned animals.

5. No other plant was found in the pasture, aside from wild onion, to which the poisoning could be attributed.

6. The poisoned cows refused to eat any ordinary feed, but when one of them was offered a bunch of wild onions she manifested a greedy appetite for them.

7. The oil which gives the species of Allium their characteristic odor is known to have an irritating effect on skin and membraneous tissues, and causes digestive disturbances if taken in excess. The bulblets of wild onion undoubtedly contain this oil in comparatively large quantities.

8. A number of plants closely allied to wild onion are definitely known to be poisonous, and some of the symptoms of poisoning produced by them, such as gastro-enteritis, coma, and paralysis, are quite similar to those shown by the cows in question.

II. ADDITIONS TO THE LIST OF PLANT DISEASES OF ECONOMIC IMPORTANCE IN INDIANA.[1]

GEORGE A. OSNER, Purdue University.

The following list of plant diseases represents collections and observations made by the writer and other members of the staff of the Botanical Department of the Agricultural Experiment Station, mainly during the past season. Specimens of the diseases listed have been deposited in the herbarium of the Department of Botany, Purdue University Agricultural Experiment Station. Unless otherwise stated the collections were made by the writer.

Barley, (*Hordeum* sp.).

Leaf Spot. *Helminthosporium sativum* P. K. B. Tippecanoe, June, 1917 (H. S. Jackson). *Helminthosporium teres* Sacc. Tippecanoe, June, 1917.

Bean, (*Phaseolus vulgaris* L.)

Leaf Spot. *Phyllosticta phaseolina* Sacc. Wells, August, 1917 (H. V. Knight). This disease has been reported previously on cowpeas.[2]

Mosaic. Cause not known, Allen, July, 1917; Tippecanoe, August, 1917. This disease was very common during the past season.

Bean, Lima (*Phaseolus lunatus* var. *macrocarpus* Benth.).

Mosaic. Cause not known. Marshall, August, 1916; Tippecanoe, July, 1917.

Blue Grass (*Poa pratensis* L.).

Ergot, *Claviceps microcephala* (Wal.) Tul. Tippecanoe, July, 1917. This disease has been reported previously on orchard grass and timothy.[3]

[1] This list is supplementary to "A List of Plant Diseases of Economic Importance in Indiana," by F. J. Pipal, Ind. Acad. Sci. Proc. 1915: 379-413, and to "Additions to the List of Plant Diseases of Economic Importance in Indiana," by Geo. A. Osner, Ind. Acad. Sci. Proc. 1916: 327-332.

Contribution from the Department of Botany, Purdue University Agricultural Station, Lafayette, Indiana.

[2] Osner, Geo. A. Ind. Acad. Sci. Proc. 1916: 328.

[3] Osner, Geo. A. Ind. Acad. Sci. Proc. 1916.

Leaf Smut. *Ustilago striaeformis* (West.) Niessl. Marshall, June, 1916; Tippecanoe, July, 1917. (See also under red top.) This disease has been reported previously on timothy.[4]

Calendula (*Calendula officinalis* L.).

Root Rot. *Corticium vagum* B. & C. Tippecanoe, July, 1917 (C. C. Rees). This disease has been reported previously on carnation, celery, potato and bean.[5]

Clover, Red (*Trifolium pratense* L.).

Leaf Spot. *Cercospora zebrina* Pass. Tippecanoe, July, 1917.

Cucumber (*Cucumis sativus* L.).

Leaf Spot. *Stemphylium Cucurbitacearum* Osner. Marshall, September, 1915; St. Joseph, September, 1915 (W. W. Gilbert); Marshall, St. Joseph, Starke, September, 1916.

June Berry (*Amelanchier Botryapium* D. C.).

Leaf Spot. *Fabrea maculata* (Lev.) Atk. Jasper, July, 1917 (Chas. Chupp). This disease has been reported previously on quince and pear.[6]

Mignonette (*Reseda* sp.).

Leaf Spot. *Cercospora Resedae* Fckl. Tippecanoe, August, 1907 (H. B. Dorner).

Pansy (*Viola tricolor* L.).

Leaf Spot. *Ascochyta Violae* Sacc. Tippecanoe, July, 1917 (F. J. Pipal).

Potato (*Solanum tuberosum* L.).

Leaf Roll. Cause not known. Laporte, Tippecanoe, July, 1917.

Mosaic. Cause not known. Tippecanoe, September, 1917.

Silver Scurf. *Spondylocladium atrovirens* Harz. Tippecanoe, August, 1917; Laporte, Floyd, December, 1917.

Wilt. *Fusarium oxysporum* Schl. Tippecanoe, Lake, August, 1917.

Raspberry (*Rubus* sp.).

Yellows. Cause not known. Laporte, August, 1917.

Red Top (*Agrostis alba* var. *vulgaris* (With.) Thurb.).

Leaf Smut. *Ustilago striaeformis* (West.) Niessl. Marshall, June, 1916; Clay, June, 1917. (See also under blue grass.)

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[4] Underwood, L. M. Ind. Acad. Sci. Proc. **1893**: 48. Pipal, F. J. Ibid. **1915**: 394.
[5] Osner, Geo. A. Ind. Acad. Sci. Proc. **1916**: 328, 331. Pipal, F. J. Ibid. **1915**: 383.
[6] Pipal, F. J. Ind. Acad. Sci. Proc. **1915**: 391, 392.

Rye (*Secale cereale* L.).

Anthracnose. *Colletotrichum cereale* Manns. Tippecanoe, June, 1917; Monroe, Allen, July, 1917 (F. J. Pipal). Severe losses were caused by this disease in several fields during the past season. This disease has been reported previously on blue grass, timothy and wheat.[7]

Stem Smut. *Urocystis occulta* (Wal.) Rab. Marshall, June, 1916; Tippecanoe, Putnam, June, 1917.

Loose Smut. *Ustilago* sp. Tippecanoe, Putnam, June, 1917; Jasper, July, 1917 (Chas. Chupp). This disease was rather rare in the three fields in which it was discovered. The fungus shows close resemblance to *Ustilago Tritici* (Pers.) Jens., but in the absence of cross inoculations it is retained as Ustilago sp.

Sunflower (*Helianthus* sp.).

Leaf Spot. *Cercospora Helianthi* E. & E. Tippecanoe, July, 1907.

Turnip (*Brassica Rapa* L.).

Albugo candida (Pers.) Rouss. Tippecanoe, October, 1915 (G. N. Hoffer). This disease has been reported previously on a number of other hosts.[8]

Wheat (*Triticum vulgare* L.).

Ergot, *Claviceps purpurea* (Fr.) Tul. Tippecanoe, Elkhart, July, 1917; Jasper, July, 1917 (Chas. Chupp). This disease has been reported previously on rye.[9]

Stinking Smut, *Tilletia Tritici* (Bjerk.) Wint. This species was reported by Pipal in 1915.[10] Further examination shows that the specimen on which the report was based was mislabeled, the species really being *Ustilago Tritici* (Pers.) Jens.

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[7] Pipal, F. J. Ind. Acad. Sci. Proc. 1915: 384, 394, 395.

[8] Underwood, L. M. Ind. Acad. Sci. Proc. 1893: 31; 1894: 153.
Wilson, G. W. Ibid. 1907: 81.
Van Hook, J. M. Ibid. 1910: 206.
Pipal, F. J. Ibid. 1915: 392.

[9] Underwood, L. M. Ind. Acad. Sci. Proc. 1893: 41.
Wilson, G. W. Ibid. 1894: 157.
Pipal, F. J. Ibid. 1915: 393.

[10] Pipal, F. J. Ind. Acad. Sci. Proc. 1915: 396.

Reaction of Culture Media.

H. A. Noyes, Purdue University.

The reaction of culture media has worried every bacteriologist at some time in his career. During the past two years there have appeared several papers, in American publications, dealing with the reaction of bacteriologic culture media. Among these may be mentioned those by Clark (1), (2), (3), (4); Itano (5); Anthony and Ekroth (6). Clark and Lubs have presented papers (3) and published a series of articles entitled, "Colorimetric Determination of Hydrogen Ion Concentration and Its Applications in Bacteriology" (4). This work, as well as all papers published to date, including those presented at the 1916 meeting of the American Society of Bacteriologists shows that bacterial activities in general are greatest when the culture medium is neutral or approximately so. A simple, practically neutral medium is most desirable for general use. Anything which tends to produce or make it necessary to adjust acidity should be avoided if possible.

Evidence points to physical and chemical laws applying to culture media just as well as they do to water solutions of pure salts, the only difference being, media are more complicated and not as fully understood. Bacteriological media are of two kinds, liquid and solid. This paper is almost entirely confined to solid media. The bases of solid media are usually agar agar, gelatin or silicate jelly. Chemicals are added to these bases to furnish food for bacterial life and to make the reaction of the media such, that bacteria may thrive. More attention has been paid to the adding of chemicals for supposed food values than to the ascertaining of the reactions that take place between the chemicals themselves and the basis of the media.

Acidity or alkalinity of culture media are due to the nature of the basic substance used in making the media, and to the nature of the chemicals added to this base. The resultant equilibrium, produced by physio-chemical phenomena, notably ionization and hydrolysis, as influenced by mass action, temperature and pressure determines the reaction of the culture media.

The two principal methods now employed to determine the reaction of media are the determination of the hydrogen ion concentration by means of the hydrogen electrode, and the total titratable acid present as determined by titration. The hydrogen electrode was applied to biochemistry by Sorensen (7). Since 1912 several investigators have used the hydrogen electrode in the study of bacterial activities. Among these are Michaelis and Marcola (8); Brunn (9); Clark (1); Itano (5); and Clark and Lubs (10).

The advantages of the hydrogen electrode in bacteriological work are claimed to be that it gives the hydrogen ion concentration the bacteria are in contact with and that it can be used advantageously in colored solutions. Its disadvantages are that it can not be used in solid media and that for every grouping of chemicals there is a new electro chemical problem. Different investigators working with the hydrogen electrode, from a purely scientific point of view, have not agreed on the contact potential between 0.1 N. HCl.—0.1 N. KCl. (11).

This paper is written not to find fault with the hydrogen electrode in its applications to bacteriology but to point out some factors in the making of culture media and in the controlling of its reaction that are as important as the method by which the reaction is determined. It is (so-called) acidity due to the crude methods of making media that is discussed in the following paragraphs.

Hot Solutions.

The usual procedure followed in titrating culture media is crude. Titrations are conducted in hot solutions (12). Hydrolysis increases with temperature and titrations of culture media containing meat, peptone, gelatine, agar agar or plant extracts when made at high temperatures are much greater than they would be at lower temperatures. The difference between hot and cold titrations is often more than the titration of the media at room temperature. Clark (1) mentions a 10 per cent gelatine, 1 per cent peptone, and 5 per cent meat media titrating plus 1.0 per cent acid when hot and plus 0.5 per cent acid at room temperature.

Small Aliquots.

Too small aliquots of media are generally used. Aliquots are pipetted or poured out from graduated cylinders. These methods of taking

aliquots allow errors as great as 10 per cent of the 5 cc. aliquot taken. An error of .5 cc., which is easily made with a graduate, means an error of 10 cc. per 100 cc. of media. Again an error of .05 cc. (one drop) of N/10 alkali in titrating means an error of plus or minus 0.1 per cent in the calculated acidity.

Indicator.

Large amounts of indicator are used. In the literature and in the standard methods (12) 1 cc. of a ½ per cent solution of phenolphthalein is specified. In accurate chemical work the amount the mass of indicator affects the accuracy of the determination is taken into consideration. One or two drops of indicator have proven sufficient. Anthony and Ekroth (6) give a list of shades of color called suitable or correct end-points with phenolphthalein. The colors listed vary from "first trace of pink" to "brilliant red." Clark (1) presents a table showing that the variations in acidity of a·1 and a 5 per cent peptone media when these media were titrated by four chemists and four bacteriologists. The acidities calculated from the titrations of the different workers varied from 0.58 cc. to 1.40 cc. N/40 alkali for the 1 per cent and from 2.68 cc. to 7.40 cc. N/40 alkali for the 5 per cent media.

Clark and Lubs (4) describe indicators, which undergo rapid color changes at certain definite hydrogen ion concentrations. They give Brom thymol blue as undergoing color changes between P_H 6.0 and P_H 7.6. These indicators are new and have been manufactured (and there, almost under protest) by only one chemical supply house. Their stability and the exactness with which they can be used under the crude conditions phenolphthalein has been used are unknown. At the present time it is fair to assume that these new indicators will come into general use, but as long as different investigators do not agree on a definite value for the contact potential between 0.1 N. HCl. and 0.1 N. KCl. phenolphthalein is not to be discarded for use under exactly defined and proper conditions.

A further evidence that phenolphthalein (properly used) is satisfactory for determining neutrality of media is found in Itano's work on the proteolysis brought about by certain bacteria when put under known initial hydrogen ion concentration. The reaction of all the media (19)

changes to very close to the hydrogen ion concentration at which phenolphthalein changes from colorless to pink.

The last report (13) of the committee on standard methods for bacteriological analysis of milk makes no recommendation as to the adjusting of the reaction of the media. This is taken as an indication of a growing realization by this committee that proper selection of materials in making media gives a media near to neutral in reaction. Other evidence that most bacteria will thrive when media are somewhere near neutral is brought out in the fact that most ensymes function when kept close to neutral.

Carbon Dioxide.

Usually some carbon dioxide is present in the alkali used, and many bacteriologists consider freshly distilled water carbon dioxide free. Carbon dioxide has affected the accuracy of some titrations, for we have reference to where investigators advise against titrating the media to a low per cent of aciditiy for fear of volatilizing ammonia from the ammonium salt used in making the media, (14). Ammonia is not easily volatilized from acid solutions but is slowly evolved by alkaline solutions even at low temperatures (40°C.), therefore these investigators are making their media nearer neutral than they think. Slightly alkaline media saturated with carbon dioxide is acid to phenolphthalein.

Apparatus supply houses are advertising water stills which, according to the advertisements, give pure distilled water. Quoting from the advertisement of one of the leading firms, we have "water of the highest purity—free from ammonia and all gaseous and organic impurities." These stills, as shown by the titrations given in the following table do not give carbon dioxide free water where the water used in them is hard. Freshly distilled water made from the same local hard water supply with different stills gave the following titrations with N/10 carbonate free alkali and phenolphthalein.*

* The water from which distilled water is prepared in many localities is as hard or harder than that in this locality.

TABLE I.

CARBON DIOXIDE IN FRESHLY DISTILLED WATER.

Titrated at room temperature 22°C.

MAKE OF STILL.	cc. N/10 Alkali per 100 cc. H_2O.	
	Water from Collecting Vessels.	Water Direct from Still Outlet.
Stokes stills—		
No. 1	0.40	.45
No. 2	0.05	.50
Barnstead still	0.08	.35
Large local plant	0.65	2.10

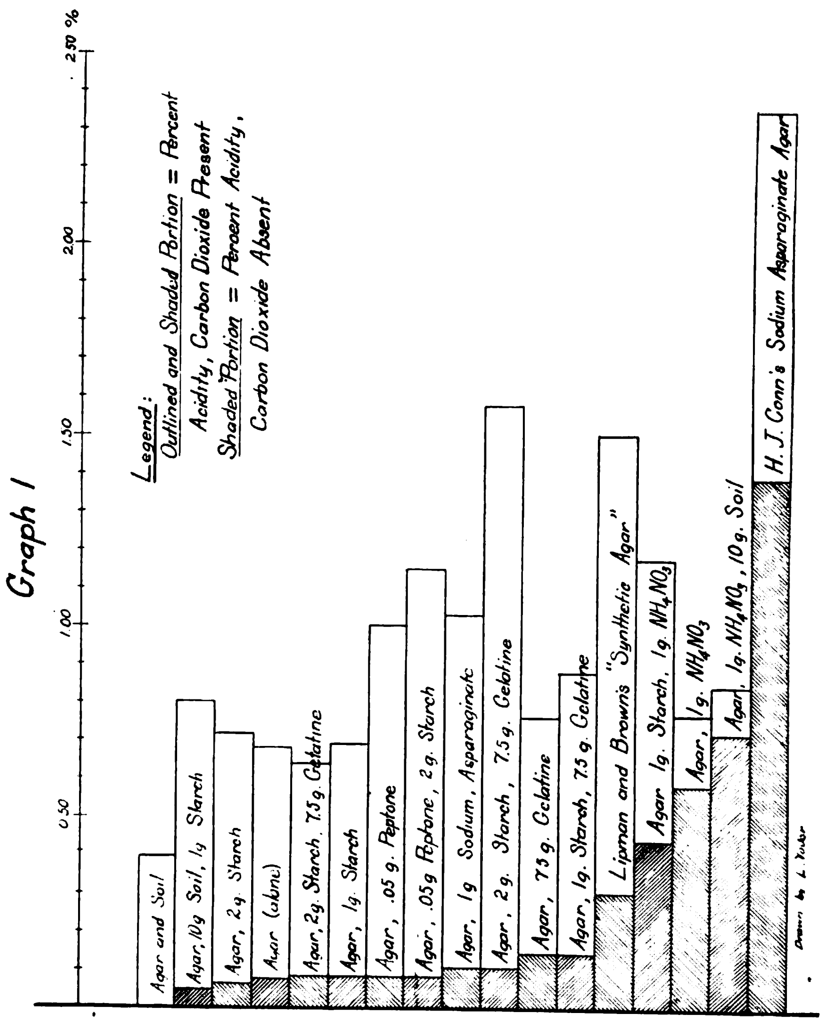
All yield water containing carbon dioxide and the amount of carbon dioxide varied with the same make as well as different makes of stills.

TEST OF EFFECT OF CARBON DIOXIDE ON MEDIA TITRATIONS.

The results reported in Table II were an attempt to find out how much the titration of media would be affected by the carbon dioxide present in distilled water from one of the above stills. The point under investigation being to determine the effect of carbon dioxide, the water was prepared and titrations were made at about 70°C. so that it would be evident that the results were not due to carbon dioxide being absorbed by the media or water from the air of the room while cooling to room temperature. Two two-liter flasks which had previously been proven to be made of non-soluble glass were filled with distilled water. The water in one flask was boiled for about five minutes to remove the carbon dioxide present while that in the other flask was heated to 75°C.

Duplicate twenty-five cc. aliquots of each media were weighed into clean, carbon dioxide free, erlenmeyer flasks; 100 cc. of the hot carbon dioxide free water was added to one of each of the duplicate aliquots of media and 100 cc. of the hot yet unboiled water added to the other flask of each set of duplicates. Two drops of phenolphthalein were added to each flask after they had been shaken until the contents appeared homogenous. Titrations were made with carbonate free N/10 sodium hydroxide* and the faintest discernible, yet permanent pink coloration

* Make a solution of the alkali (sodium) so strong that the carbonate contained will be precipitated. Add the clear supernatant liquid which is carbonate free to carbon dioxide free water and standardize.


Graph I
Legend:
Outlined and Shaded Portion = Percent Acidity, Carbon Dioxide Present
Shaded Portion = Percent Acidity, Carbon Dioxide Absent
0.50
1.00
1.50
2.00
2.50 %
Agar and Soil
Agar, 10 g Soil, 1 g Starch
Agar, 2 g. Starch
Agar (alone)
Agar, 2 g. Starch. 7.5 g. Gelatine
Agar, 1 g. Starch
Agar, .05 g. Peptone
Agar, .05 g Peptone, 2 g. Starch
Agar, 1 g Sodium, Asparaginate
Agar, 2 g. Starch, 7.5 g. Gelatine
Agar, 7.5 g. Gelatine
Agar, 1 g. Starch, 7.5 g. Gelatine
Lipman and Brown's "Synthetic Agar"
Agar 1 g. Starch, 1 g. NH4NO3
Agar, 1 g. NH4NO3
Agar, 1 g. NH4NO3, 10 g. Soil
H. J. Conn's Sodium Asparaginate Agar
Drawn by L. Yoder

was taken as the end point. The results of these tests with 23 lots of media are shown in Table II and Graph I.

TABLE II.

ACIDITY OF MEDIA (*CALCULATED IN PER CENT.) AS AFFECTED BY CARBON DIOXIDE IN DISTILLED WATER.

	(1) CO_2 Present in Dilution Water.	(2) CO_2 Free Dilution Water.	(3) Acidity Due to CO_2 in (1).	(4) Actual Acidity if Corrected to .80 by (1).	(5) Actual Acidity if Corrected to .50 by (1).
Agar† (alone)	.68%	.07%	.61 (c)	.19	alk.
Agar and 1 gm. starch	.69	.08	.61	.19	alk.
Agar and 2 gm. starch	.72	.06	.66	.14	alk.
Agar and 10 gm. soil	.39	.00—	.39+	—.41	alk.
Agar and ammonium nitrate	.76	.58	.18	.62	acid.
Agar and 7.5 gms. gelatine	.72 (a)	.12	.60	.20	alk.
	.80	.16	.64	.16	alk
Agar and .05 gms. peptone	1.00	.08	.92	—.12	alk.
Agar and 1.0 gms. sodium asparaginate	1.03	.10	.93	—.13	alk.
Agar, 1 gm. starch and 10 gms. soil	.80	.04	.76	.04	alk.
Agar, 1 gm. starch and 1 gm. (ammon. nitrate (b))	1.18	.44	.74	.06	alk.
Agar, 1 gm. starch and 7.5 gelatine	.66	.11	.55	.25	alk.
	1.10	.16	.94	—.14	alk.
Agar, 2 gm. starch and 7.5 gelatine	1.58	.10	1.48	—.68	alk.
Agar, 2 gm. starch and .05 gm. peptone	1.15	.08	1.07	—.27	alk.
Agar, 10 gms. soil and 1 gm. (ammon. nitrate)	.84	.72	.12	.68	acid.
Agar, 10 gms. soil, 2 gms. starch and 7.5 gelatine	.64	.08	.56	.24	alk.
Lipman and Brown's "synthetic agar"	1.25	.22	1.03	—.23	alk.
	1.40	.28	1.12	—.32	alk.
	1.48	.32	1.16	—.36	alk.
	1.87	.36	1.51	—.69	alk.
H. J. Conn's (sodium asparaginate agar)	2.24	1.38	.86	—.06	alk.
	2.46	1.40	1.06	—.26	alk.

*1.00% would mean the requirement of 1 cc. normal alkali for neutralization of 100 cc. of media.

†Fifteen grams of air dry agar basis of all media.

(a) Each figure given represents one lot of media. No two lots of same media were made on same date.

(b) Phenolphthalein is not the most desirable indicator to use when ammonium salts are present.

(c) Distilled water prepared from soft water is often practically free from carbon dioxide.

The table shows—

(1) That the carbon dioxide normally present in distilled water prepared from hard water by a modern still affects the titration of media.

(2) That the titration, due to carbon dioxide present in diluting water may be much greater than the total titration of the acidity of the media itself.

(3) That the carbon dioxide does not affect the acidity of all media in the same proportion.

(4) Media adjusted by results of titrations made of aliquots diluted

with water containing carbon dioxide are always less acid than desired, in fact some media are alkaline, note columns headed (4) and (5).

Distilled water is believed *by so many* to be carbon dioxide free, no matter whether the water from which it is made is hard or soft, that, as a rule bacteriologic culture media has been adjusted to a less degree of acidity than planned for. Litmus is not sensitive to carbonic acid, thus it seems fair to assume that acidities of culture media, observed with phenolphthalein, but which do not prove out with litmus may be partly due to the carbon dioxide present in the dilution water added to the aliquot titrated. Anthony and Ekroth (6) make statements concerning the work of MacNeal, Muir and Ritchie, Stilt, and others concerning comparisons between litmus and phenolphthalein titrations. Titrations with phenolphthalein carried out near the boiling point of the media are unreliable, due to the increased hydrolysis of the media and to the fact that phenolphthalein is more sensitive in cold solutions (15).

Hot and Cool Titrations With Especially Prepared Media.

An experiment was conducted to find out the effect of temperature on acidity titrations when agar agar plus gelatin were present with salts that undergo changes in hydrolysis with increasing temperature. The agar agar and gelatin used were selected because of their small changes in acidity when autoclaved or heated. They were selected by a procedure described by the author (16) in another article. Unfiltered water solutions of the agar and gelatin used were free from precipitates and thus by themselves did not even need filtering.

Two basic media were made up according to the following procedure:

Agar agar Media.—Thirty grams of agar agar were dissolved in the inner part of a double boiler in 2,000 cc. of carbon dioxide free distilled water. When solution was complete distilled water (carbon dioxide free) was added to make the weight of agar and water up to 2,000 gms.

Agar plus Gelatin Media.—This was made up exactly as the agar media except that 7.5 grams of gelatin were added per 1,000 grams of media.

Fifty gram aliquots of each media were weighed out into clean 250 cc. erlenmeyer flasks. Thirty-four aliquots of each media were taken. The chemicals were previously prepared by making water solu-

tions of them of such concentration that they contained .05 grams of salt per cc. of solution. One cc. aliquots of the proper solutions were added to aliquots of the media using a 1 cc. pipette graduated to .01 cc. This was to give a concentration of the salt of 1.0 gram per liter of media.

The flasks were tightly plugged with cotton and autoclaved for different lengths of time under 17 pounds pressure of live steam. It was assumed from previous tests that the one cc. of water added with the salt would be lost in the autoclaving. As soon as autoclaved approximately 100 cc. of boiling carbon dioxide free distilled water was added to each flask. Titrations were made at the temperatures specified using 2 drops of 0.5 per cênt solution of phenolphthalein as indicator and N/10 *carbonate free* sodium hydroxide. The results are given in Table III.

TABLE III.

ACIDITY OF AGAR AGAR AND AGAR PLUS GELATINE MEDIA AS AFFECTED BY SALTS AND LENGTH OF TIME OF STERILIZATION.

(Figures express cc. normal alkali needed to neutralize 100 cc.)

	Hot 90°.	40° to 45°.	Increase 90° Over 40°.	(1) Increase Due to Salts. 90° 40°.	(2) Increase Due to Gelatin. 90° 40°.
Potassium nitrate (3)	.03	.01	.02		
Ammonium nitrate (3)	.30	.30	.50		
Aluminum nitrate (3)	.84	.80	.04		
Agar—					
Autoclaved 0.0 hours	.03	.01	.02		
Autoclaved 0.5 hours	.04	.03	.01		
Autoclaved 1.0 hours	.04	.03	.01		
Autoclaved 2.0 hours	.03	.03	.00		
Autoclaved 4.0 hours	.03	.03	.00		
Average			.008		
Agar and KNO_3—					
Autoclaved 0.5 hours	.05	.03	.02	.01 .00	
Autoclaved 1.0 hours	.05	.03	.02	.01 .00	
Autoclaved 2.0 hours	.05	.04	.01	.02 .01	
Autoclaved 4.0 hours	.03	.03	.00	.00 .00	
Averages			.013	.01 .003	
Agar and NH_4NO_3—					
Autoclaved 0.5 hours	.36	.21	.15	.32 .18	
Autoclaved 1.0 hours	.38	.20	.18	.34 .17	
Autoclaved 2.0 hours	.35	.20	.15	.32 .17	
Autoclaved 4.0 hours	.40	.18	.22	.37 .15	
Averages			.175	.338 .168	

TABLE III—Continued.

	Hot 90°.	40° to 45°.	Increase 90° Over 40°.	(1) Increase Due to Salts. 90°	40°.	(2) Increase Due to Gelatin. 90°	40°.
Agar and Al $(NO_3)_3$—							
Autoclaved 0.5 hours	.71	.62	.09	.67	.59	....	
Autoclaved 1.0 hours	.73	.63	.10	.69	.60	....	
Autoclaved 2.0 hours	.75	.60	.15	.72	.57	....	
Autoclaved 4.0 hours	.78	.68	.10	.75	.65	....	
Averages	....	....	.110	.708	.602		
Agar plus Gelatin—							
Autoclaved 0.0 hours	.11	.07	.04	....		.08	.06
Autoclaved 0.5 hours	.12	.10	.02	....		.08	.07
Autoclaved 1.0 hours	.13	.10	.03	....		.09	.07
Autoclaved 2.0 hours	.13	.08	.05	....		.10	.05
Autoclaved 4.0 hours	.13	.10	.03	....		.10	.07
Averages	....	....	.034	....		.09	.064
Agar plus Gelatine and KNO_3—							
Autoclaved 0.5 hours	.11	.10	.01	-.01	.00	.06	.07
Autoclaved 1.0 hours	.10	.10	.00	-.03	.00	.05	.07
Autoclaved 2.0 hours	.13	.10	.03	.00	.02	.08	.06
Autoclaved 4.0 hours	.13	.10	.03	.00	.00	.10	.07
Averages	....	....	.018	-.010	.005	.073	.068
Agar plus Gelatin and NH_4NO_3*—							
Autoclaved 0.5 hours	.53	.29	.24	.41	.19	.17	.08
Autoclaved 1.0 hours	.53	.28	.25	.40	.18	.15	.08
Autoclaved 2.0 hours	.53	.18	.35	.40	.10	.18	—.02
Autoclaved 4.0 hours	.58	.38	.20	.45	.28	.18	.20
Averages	....	....	.26	.413	.188	.17	.085
Agar plus Gelatin and Al $(NO_3)_3$*—							
Autoclaved 0.5 hours	1.03	.99	.04	.91	.89	.32	.37
Autoclaved 1.0 hours	1.03	.98	.05	.90	.88	.30	.35
Autoclaved 2.0 hours	1.03	.91	.12	.90	.83	.28	.31
Autoclaved 4.0 hours	1.13	.88	.25	1.00	.78	.35	.20
Averages	....	....	.115	.928	.845	.313	.308

*Precipitation occurred in all aliquots of this series.

(1) Figures in this column are difference between the media without and with added salt.

(2) Figures in this column are difference between corresponding media containing no gelatin.

(3) These salts were used because they are typical of classes of salts that vary in hydrolysis.

Table III brings out the following:

(1) The temperature of the media affects the titration.

(2) The effect of temperature on titration varies with the bases of the media and the chemicals used in making the media.

(3) Increasing length of time of autoclaving does not appreciably change the acidity of the media.

(4) Potassium nitrate did not appreciably change the acidity of the agar or the agar plus gelatin media.

(5) The effect of the nitrates used seemed to be due more to the hydrolysis of the nitrates themselves rather than to reactions taking place between them and the agar and gelatin.

(6) Reaction of media should be adjusted by titrations made at the temperature at which they are to be used.

The results of this test lead one to presume that if proper care was used in selecting the chemicals to be used in culture media, the acidity of bacteriologic culture media would rarely have to be neutralized.

Evidence Drawn From Literature in Support of Contention That Hydrolyzable Substances Should Be Avoided.

Anthony and Ekroth (6) give a table which shows the reaction of different peptones when titrated at room and boiling temperatures with phenolphthalein as indicator. The results show that the variations in acidity of the different peptones are large but that the peptone having the lowest acidity at room temperature also has the lowest at boiling temperature. Witte's peptone has been almost universally agreed upon as the best and is it not fair to suppose that this is due to its freedom from hydrolyzable material?

The same authors found that "Leibig's Extract of Beef" does not undergo the hydrolysis that homemade extracts do. They say, "This stability is due probably to very prolonged heating in the preparation of the beef extract itself." In other words the more stable the extract the more reason for its use.

Itano (5) working with the hydrogen electrode finally, after experimentation, decided on a medium containing both "Leibig's extract" and Witte's peptone. He found that if these constituents were sterilized before mixing, i. e., if they were stabilized, "the medium prepared from them maintained the figured P_H fairly constantly."

Fellers (17) finds that soil bacteria prefer a very slightly acid, a neutral or just alkaline media.

Summarizing the results obtained by these recent workers and realizing that the standard method of titrating media (12) gives too high titrations and thereby low acidity of adjusted media, it seems probable that bacteriologic media in most cases should be very slightly acid or neutral in reaction.

The following procedure which is based on results reported in Tables

I, II and III, has proven satisfactory for the titration of media: Twenty-five gram aliquots of the hot media are weighed out into 350 cc. erlenmeyer flasks (Jena, pryex or non-sol), which have just been rinsed with carbon dioxide free water. Approximately 250 cc. of hot, carbon dioxide free distilled water is added to each flask and the flasks are shaken until after the mixture of water and media appear homogeneous. They are then loosely stoppered and set to one side until they attain room temperature. Titrations are then made with N/10 carbonate free alkali and two drops of a ½ per cent solution of phenolphthalein. The end point is reached on the appearance of the faintest, yet permanent pink color. The fainter the color one is able to titrate to, the more accurate the titration.

SUMMARY.

(A) Ideal media for routine bacteriological work, if rightly prepared from selected agar agar from stabilized peptone, from stabilized meat extracts and from chemicals which hydrolize but little, does not need to be adjusted in reaction unless the chemicals inter-react (which should lead to a choice of other chemicals).

(B) It is fairly well established that most bacteria will thrive in a neutral medium. The standard methods (12) have allowed media to be adjusted to nearer neutral than the figures would indicate.

(1) Titrations have been carried out in hot solutions where hydrolysis is great and media corrected to certain standards by these titrations is always nearer neutral when at blood heat or a lower temperature.

(2) Many have used alkali and water containing carbon dioxide and the errors resulting have caused media to be adjusted to lower acidity than desired.

(C) Hydrolyzable chemicals have been used and their use has made results uncertain.

(D) Meat infusions, peptones, and other extracts have been found to vary greatly in reaction. Those extracts and peptones giving best results happen to be those that are most stabilized.

(E) Some organizims tolerate more acidity than others (3) and the hydrogen ion concentration must be determined if classifications are to be made on the basis of tolerance to H and OH ion concentrations.

(F) Workers in physical chemistry have determined that for each acid there is a dilution beyond which the per cent ionized remains constant. When 25 cc. of media that is, at most, only slightly acid is further diluted with carbon dioxide free water (as must be done to titrate at room temperature) the per cent acid ionized has reached its limit. The difference between the value obtained with the hydrogen electrode and that obtained by titration under proper conditions is thus small or negligible.

(G) Itano (5) (19) has found that proteolysis is optimum when the hydrogen ion concentration of media is in or at the range where phenolphthalein titrations properly carried out would indicate neutrality.

Different investigators have suggested brom thymol blue and phenol red for phenolphthalein. This has not been done because the paper is intended to bring out errors in making media which must be corrected if any indicator is used. The values used at present for the contact potential prevent one from adopting any shade of any indicator as absolute neutrality.

The author wishes to make acknowledgment to Dr. Redfield of the Bureau of Chemistry for criticisms and suggestions. Acknowledgments are also due to Director C. G. Woodbury, for it is only with his consent that the writer can devote any time to consideration of this subject.

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Studies on Pollen.

F. M. Andrews—Indiana University.

Since the time of Amici it has been known that pollen grains germinate and send out one or two tubes. Amici carried on his studies on this point on the plant Portulaca oleracea. Ever since the work of Amici various investigations have been made on the germination of pollen and especially concerning the different conditions that would promote its growth. Even yet, many points remain obscure and much investigation will be necessary before these are solved. As the chemical nature of the stigmatic fluid is complicated and varies greatly in different plants, it renders the culture medium used to induce growth a matter of one experiment after another with different media in order to ascertain which will induce growth or is best adapted to the various cases. Of course it is known that in a good many cases a sugar solution will cause growth, but this is by no means the case with the pollen of all plants, so that other means frequently have to be tried. Moreover the physical character of the culture medium is a factor that has been very generally overlooked.

In the experiments here mentioned I have investigated to date the behavior of the pollen of 435 plants with respect to a culture medium of cane sugar. Of these, 110 showed no response whatsoever as no growth occurred. The remainder showed a more or less pronounced growth. A wide range in the percentage of the cane sugar solutions was used so that ample opportunity for growth was afforded by this medium if such a medium would produce it. Plants from many different families as well as from the same family were tried so as to see in how far differences in germination under such conditions would occur.

Stoppage of a Sewer Line by Roots of Acer Saccharum.

F. M. Andrews—Indiana University.

The many well-known examples of stoppage of sewer and pipe lines is probably exceeded from the standpoint of time, at least, by the following example:

A six-inch sewer pipe line was laid five feet deep between two trees of Acer saccharum. For two years the line remained perfectly clear of all obstruction and no difficutly was experienced. Late in the summer of the third year a stoppage of this line suddenly occurred. The trees above referred to are 21 years old, about 6 inches in diameter and about 50 feet high and are vigorous specimens. They stand on a west exposure and on a bank in the open where they are subjected to the direct rays of the sun. The bank was a narrow one, so that the ground was quickly dried out and the most actively growing part was excessively dry. This caused the roots to grow down very quickly in search of water and to escape the upper and lateral very dry layers of the soil. On nearing the pipes there was also a chemotactic attraction exerted. The roots finding a small opening grew in quickly, effecting a complete closure of the tile line for a distance of fifteen feet. By their further quick growth, especially after entrance, the heavy cement joints were completely ruptured. The sewer line was replaced in the region affected by heavy double-hub cast-iron pipe whose joints were sealed with lead. Within the space of a few months, therefore, the roots of these trees had completely blocked the pipes. The universally known tendency of Populus deltoides as well as the roots of other trees and plants to grow into sewer and water pipes is common knowledge. The location of the stoppage in a sewer line may be ascertained with comparative accuracy. This can be easily done, since one can ascertain the volume of a given section of the pipe and the metered volume of water required to fill the pipe from stoppage to the water supply, due consideration of course to be paid to those cases in which the stoppage may not be complete and where some water may pass through.

ANTHOCYANIN OF BETA VULGARIS.

F. M. ANDREWS—Indiana University.

If a freshly made solution of chlorophyll is placed in a transparent vessel in the direct sunlight it is well known that in a few hours the chlorophyll will be broken down and will become more or less brown in color. If, however, part of the freshly made solution of chlorophyll is placed in the dark it will remain apparently unchanged in color even after twenty-four hours or longer. The above mentioned behavior of chlorophyll acts quite differently from the anthocyanin of Beta vulgaris. The anthocyanin of this plant forms one of those examples where the pigment forms in the subterranean parts. The behavior of this pigment with reference to the light is quite different as regards preservation in the light. If a strong solution of the anthocyanin of Beta vulgaris is placed in a test-tube in darkness it will continue to preserve its normal color for more than a week. Quite different from chlorophyll if a strong solution of this anthocyanin is exposed in a test-tube in direct sunlight it will retain its normal bright color for a week, or sometimes more, or until broken down and disorganized by bacterial action. This latter effect finally happens to the solution of anthocyanin of Beta vulgaris in the dark. So that whether in the light or dark the color remains almost the same length of time. While it is clear that the presence of anthocyanin in various plants is not important like chlorophyll, still a comparative, exhaustive study of the two pigments under different physiological conditions is much to be desired and would make a valuable contribution.

Improved Forms of Maximows' Automatic Pipette.

F. M. Andrews—Indiana University.

Grafe[1] figures and describes thé automatic pipette of Maximows (Fig. 1). The pipette as given by Maximows is very practical but is in part difficult of manipulation and needs some improvements, which I have supplied. In the first place a Woulfe bottle with three openings at the top is not necessary nor is a bottle with a tubulure at the base absolutely essential, although it is convenient. Any bottle having an opening at the top and provided with a stopper having four holes is sufficient. The funnel shown in Maximows' drawing is also unnecessary. If, as Grafe describes, one closes A and B (Fig. 1), and opens C the NaOH in D flows out, creating a partial vacuum in D and causing the desired solution, in this case baryta water, to rise in the pipette E if the pinch cock F is open. If now one opens B air will enter D, allowing the solution in E to sink and thus measure the quantity of fluid. In this last operation is the chief difficulty, for when B is closed after opening the solution in E will generally not cease to sink at once owing to the reduced pressure in D produced by the column of solution in E. Since accuracy is the prime consideration here a slight error is fatal for correct results. Furthermore the glass tube B should extend below the surface of the NaOH or KOH solution to insure the removal of all CO_2 and the outside air not be allowed to enter too rapidly. Also it will be seen according to Fig. 1 that the NaOH or KOH solution would be wasted in the Maximows apparatus. The control of the outflow of the solution in E should be for the sake of accuracy and convenience not at B but at the lower end of the pipette E. Maximows used the funnel A for refilling, which is unnecessary.

The above difficulties I have removed by a modification of Maximows' apparatus as shown in Figs. 2, 3, and 4, which I will now briefly describe. In both Figs. 2 and 3, which are photographs, bottles with one opening at the top could be used instead of the Woulfe bottles.

[1] Grafe. Dr. Viktor--Ernährungsphysiologisches Praktikum der höherer Pflanzen, p. 360.

Fig. 2 shows the apparatus in a position on the ring stand A for filling the pipette E. If one opens C the NaOH solution in D will run into G which, when I is open, will cause the baryta solution to rise in

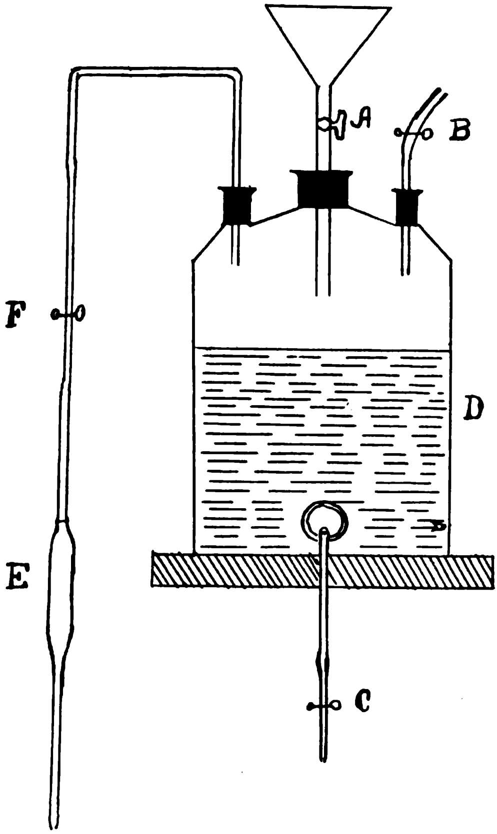
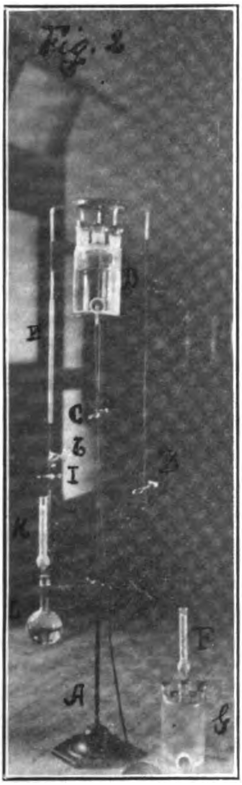
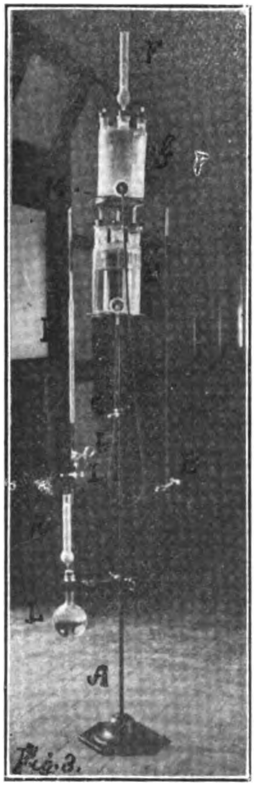


Fig. I.

E to the desired height. If now C and I are closed and B opened it will allow the air to enter D when J is opened and the solution allowed to run out. The NaOH or KOH solution in D will arrest any CO_2 present so that the baryta solution will remain clear. The baryta solution in L remains clear since the calcium chloride tube K, which contains

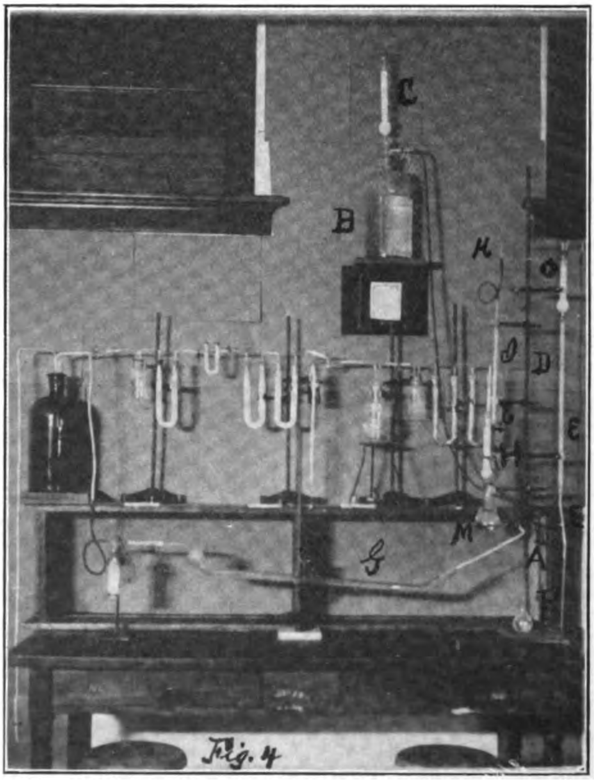
soda lime, extracts the CO_2 of the air as it enters L when any of the solution is drawn into the pipette E. The solution of NaOH or KOH in D in Fig. 1 is not used further after escaping according to Grafe's figure. In Fig. 2 I show that it is collected in another bottle H, which





is similar in size and construction to D. By elevating the bottle G to a position M on the ring stand A above D and opening J, as shown by Fig 3, the same solution of NaOH or KOH runs back into D and can be used again. By this apparatus a large number of measurements may be quickly and very accurately made. The tube F with soda lime is not necessary in Figs. 3 and 4 since the KOH removes the CO_2.

Figure 4 is a photograph of the apparatus used by Detmer[1] for estimating the amount of CO_2 produced by plants, and including also the titrating apparatus for measuring used by him. The apparatus as shown in Fig. 4 is given only to demonstrate an improved form of



Maximows' automatic pipette, which may advantageously be used in connection with the Detmer apparatus.

If one opens the pinch cock A (Fig. 4), the baryta water in B, freed from the CO_2 by the soda lime in C, flows into the burette D as shown by Detmer and the air in D escaping through E. If now one

[1] Detmer, W.—Practical Plant Physiology. Translation by S. A. Moor, pp. 264 and 267.

closes A and E and opens F the measured baryta water in D will flow into the Pettenkofer tube G. This outflow from D will cause the baryta water in the Erlenmeyer flask M to rise in the pipette I. It goes without saying that for convenience the capacity of D and I should be equal. Next close F and H and open E and J. The air will then enter E when the CO_2 will be removed by the soda lime in O before entering I through K. This will allow the measured baryta water in I to flow out of J into a suitable vessel for titration. In this way the baryta water measured into G, through which CO_2 is to be passed, furnishes the power in a convenient way for filling and accurately measuring an equal amount in I, through which the CO_2 of respiring plants is passed for comparison.

THE EFFECT OF CENTRIFUGAL FORCE ON PLANTS.

F. M. ANDREWS—Indiana University.

The effect of the successive displacement of contents in plant cells has never been carried out to the full extent. This would be an interesting piece of research in as much as it would show not only the capacity of plant cells to resist possible injury by repeated displacement of the contents over long periods, but also that it would demonstrate the recuperative power of such cells. Especially if this latter began to diminsh it would be important to know when and how rapidly the protoplasm reacted in this respect. I have already performed a few experiments of this kind where, however, the contents of Closterium moniliferum was displaced only a few times successively.[1] Approximately no difference was noticed in this plant when centrifuged successively a few times and the specimens kept in the dark.

I have more recently tried the same experiments on Oedogonium ciliatum with similar results. The following four experiments will show the response of the plant when centrifuged 15 minutes at 26°C. I centrifuged Oedogonium ciliatum, using 1,500 gravities. All the contents were displaced which returned in the light in 7 days. After the second centrifuging the contents returned in 6½ days. After the third centrifuging in 6 days and after the fourth centrifuging in 6½ days. Clearly, from these few experiments, the protoplasm is apparently not detrimentally affected and shows that a large number of such experiments would be necessary to determine this point. There are interesting questions to be ascertained in such experiments, among them being that of the response of the protoplasm to certain stimuli when the contents are displaced.

[1] Jarbücher für wissenschaftlichen Botanik, 1915, Vol. 56, pp. 229-233.

THE EFFECT OF AERATION ON THE ROOTS OF ZEA MAYS.—I.

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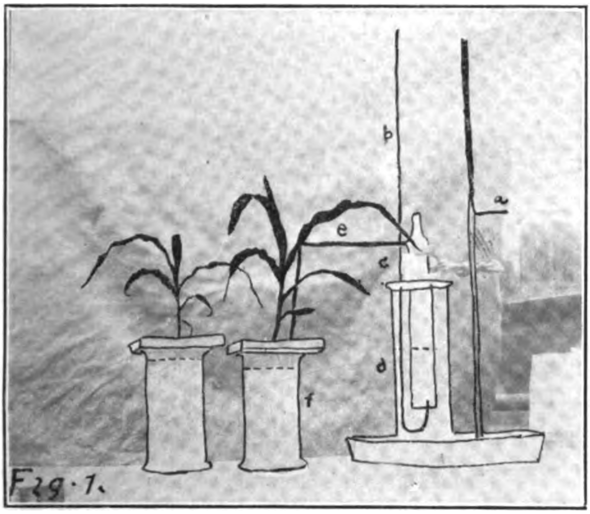
This experiment was conducted for the purpose of learning the effect of aeration on the roots of Zea Mays. In water cultures as commonly conducted, the only aeration that the growing plants receive comes from the surface of the water.



Effect of aeration on roots of Zea Mays.

The plants were grown as water cultures in normal solutions minus the sodium chloride. The cylinders used had a capacity of one and one-half liters and the solution was changed at frequent intervals. One cylinder was aerated by means of letting a stream of water flow through a glass tube (a) from a hydrant. The tube protruded slightly through a rubber cork fitting tightly in the larger end of condensing tube that was cut in two pieces. The cork should have an opening for a tube to admit air. The lower end of the tube was connected to a second one (b) leading to a cylinder (d) filled with water resting in a drain pan. The

larger end of a cutoff condensing tube (c) was suspended over the open end of the small bent tube. The upper end was connected to the cylinder of solution by a glass tube (e) which extended almost to the bottom of f. All connections between the glass tubes were made by tight-fitting rubber tubing. The flow of air was regulated by varying the amount of water that passed through the hydrant. A drain tube carried away the excess of water from the pan. The apparatus stood about four feet high and was held in an upright position by a ring-stand.

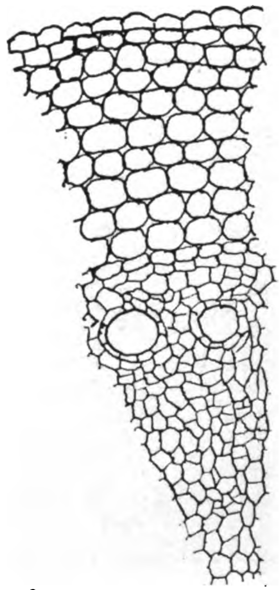


Fig. 2

Effect of aeration on roots of Zea Mays

This apparatus was after W. Ostwald as given in his *Chemico-physical Measurements.* Aeration of plants is mentioned, however, by Julius Sachs in his *Vorlesunger über Pflanzen-physiologie,* 1887, pages 268-269.

The glass tube fed a constant supply of air into the cylinder of normal solution. The two plants were started at the same time and received like treatment except the aeration of the solution.

The following table gives the height of the plants at different stages of growth:

	Aerated.	Nonaerated.
2 days	2.8 cm.	1.9 cm.
3 days	5.9 cm.	4.7 cm.
6 days	14.50 cm.	12.00 cm.
8 days	25.00 cm.	23.00 cm.
11 days	28.00 cm.	24.00 cm.
15 days	37.00 cm.	33.00 cm.
20 days	47.00 cm.	37.00 cm.
26 days	65.00 cm.	46.00 cm.

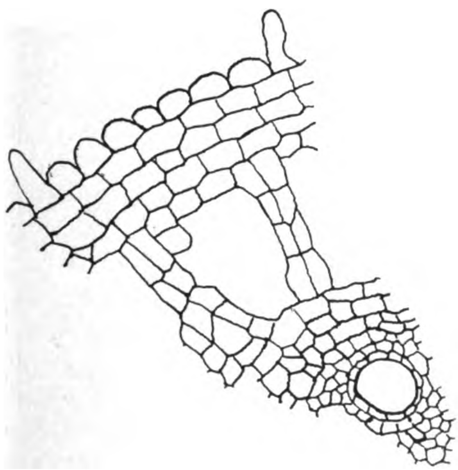


Fig. 3.

Effect of nonaeration on roots of Zea Mays.

After three months' growth in the greenhouse under as nearly normal growing conditions as possible, the plants were removed and burned. The ash of the aerated plant including the roots weighed 2.182 grams, while the ash of the nonaerated amounted to 1.303 grams.

A cross-section of a root when magnified showed that the cortex cells of the aerated plant (Fig. 2) were uniform in size with no con-

spicuous air cavities, while the cortex of the nonaerated root (Fig. 3) contained large air cavities separated by narrow strands of tissue.

This experiment shows the great importance of the presence of air not only for the normal growth of plant tissue but also the obtaining of the maximum plant growth.

The work of which this study is the result was taken up at the suggestion of Prof. Andrews of the Department of Plant Physiology of Indiana University, and his constant interest and help have contributed to its completion.

Resistance of Mucor Zygotes.

Mildred Nothnagel—Florida Experiment Station.

In the fall of 1916, while attending Indiana University, various experiments were begun to test out the resistance of Mucor zygotes and spores to desiccation, to heat, and to different chemicals.

Fortunately the writer had a good culture of zygote material from which fresh zygotes could always be raised. Since the zygotes are supposed to be more resistant than the asexual spores, the experiments were made with the former in order to make them more conclusive.

After sterilizing the bread, inoculating it with zygotes, placing in a dark place, room temperatures, zygotes in unlimited number would be found in 5 to 7 days.

The work was carried out along several lines, and in all cases, unless otherwise stated, zygotes that had been just freshly matured, and those a year old, were used in order to make comparison.

Outline of Work.

1. Resistance of zygotes to desiccation.
2. Resistance to heat of zygotes in the desiccator.
3. Resistance to heat of zygotes upon oven-dried bread.
4. Resistance to heat of zygotes placed upon bread with its normal amount of moisture present.
5. Resistance to heat of zygotes in presence of large amount of moisture.
6. Resistance of zygotes to various chemicals.

In all the experiments the utmost care was used to have everything sterile and, in case water or nutrient material had to be added, every precaution was taken so that spores from the outside would not be introduced. Control experiments were run for the purpose of checking.

1. *Resistance of Zygotes to Desiccation.*—Into sulphuric acid desiccators were placed numerous cultures of the one-year zygotes as well as the freshly matured zygotes with no nutrient material. These cultures

were left in this environment for various lengths of time ranging from one week to one year. At the end of these respective periods the small dish with the mucor within it was removed, and with the utmost care a piece of moist, sterilized bread was introduced, after which it was set aside in a warm, dark place.

In all cases but the last one a vigorous growth was made within seventy-two (72) hours and in many cases zygotes were found within a week.

The results of the cultures remaining in the desiccator for one year were not very conclusive, due to a slight accident. The culture of the zygotes, that was freshly matured when it was placed in the desiccator, produced growth within twenty-four (24) hours, and sporangia within forty-eight (48) hours, but the culture with the older zygotes in it failed to grow within two (2) weeks after being removed from the desiccator and moistened, though upon further moistening a vigorous growth was produced. Unfortunately, though, when the culture was being moistened the second time the lid slid off for an instant and there is a slight possibility of spores from the outside gaining entrance.

In one of the first experiments performed, growth failed to take place until further moistening, and it is the belief of the author that such was the case in this last experiment.

2. *Resistance to Heat of Zygotes in Desiccator.* — Zygotes were placed upon oven-dried bread, put in a sulphuric acid desiccator, and then placed in an oven at 60 degrees centrigrade for various lengths of time, ranging from seventy-two (72) hours to five (5) weeks. At the end of these periods a culture would be removed and the bread moistened with sterile water. In all the cultures the zygotes survived the heat, and within forty-eight (48) hours after being removed there was a vigorous growth, in many cases zygotes being formed within a week.

Another set of experiments was run along similar lines, through in this case the temperature was raised to seventy (70) degrees centigrade, the time ranging from one week to one month. In the case of the freshly matured zygotes, or as will hereafter be termed *New Zygotes,* a culture was able to survive two (2) weeks of heat and desiccation, though at the end of three (3) weeks, no growth took place when placed in favorable environment. The one year old zygotes were not

able to withstand the heat and desiccation for two (2) weeks, though the culture that had been in the heat for one week germinated readily.

3. *Resistance to Heat of Zygotes Upon Oven-dried Bread.*—The bread was first dried in an oven, the temperature of which was kept at 110-120 degrees centigrade for several hours. In each test tube was placed a small cube of this bread, which had been inoculated with zygotes; the test tubes were plugged with cotton, and then placed in the oven at 100 degrees centigrade for different lengths of time ranging in close series from 1 min. to 25 min. After the cultures were removed and allowed to cool the bread was moistened with sterile water. In every instance, up to and including those remaining in the heat for 17½ minutes, zygotes were produced within a week; but in those cultures remaining in the heat 20, 22½, and 25 minutes, no zygotes were formed, though there was a vigorous growth.

Other cultures were placed in the oven at a temperature of 60 degrees centigrade. This experiment is scarcely complete, since the various lengths of time were not close enough together to warrant any conclusions. Cultures remaining in this heat for one week grew vigorously after being removed to suitable environment; but those remaining in the heat for five weeks failed to germinate after being removed to room temperature and moistened.

The third set of experiments under this heading was placed in an oven at seventy (70) degrees centigrade, the duration being from four (4) days to three (3) weeks. New zygotes produced growth after they had remained at seventy (70) degrees centigrade for two (2) weeks, though at the end of three (3) weeks there was no sign of germination. Old zygotes did not resist the heat as long, the longest duration being one week.

4. *Resistance to Heat of Zygotes in Presence of Small Amount of Moisture.*—In these cultures the amount of moisture was that which is ordinarily found in fresh bread. Experiments placed in the oven at sixty (60) degrees centigrade for one week showed no growth after being removed to favorable environment and neither did cultures after being in the oven for only forty-eight (48) hours at this temperature.

5. *Resistance to Heat of Zygotes in Presence of Large Amount of Moisture.*—These experiments were performed, first, by thoroughly soak-

ing small cubes of bread, placing one in each test tube, sterilizing them, and then inoculating the bread; after which the test tubes were tightly plugged and placed in warm water the temperature of which ranged from forty-five (45) to seventy (70) degrees centigrade.

The following table will give the temperature and the longest time for each of these temperatures that the zygotes were able to remain in it, and still retain the power of germination.

TABLE I.

	70°C.	65°C.	60°C.	55°C.	50°C.	45°C.	40°C.
1 yr.. Zygotes	0 min.	1 min.	2 min.	4 min.	10 min.	30* min.	45* min.
New Zygotes	0 min.	3 min.	5 min.	10 min.	15 min.	30* min.	45* min.

*Experiments of longer duration were not made for this temperature.

6. *Resistance of Zygotes to Various Chemicals.*—The resistance of the zygote and the growing mycelium toward a few chemicals was tested out. Molecular solutions of NaCl (common salt), Fe_2Cl_6 $12H_2O$, $CuSO_4$, and C_2H_5OH (ethyl alcohol) were the solutions used and were the only moisture that the germinating zygotes and growing mycelia received. Oven-dried bread was moistened with the chemical and then inoculated with zygotes after which the cultures were set aside in a warm, dark place to germinate. The first column of Table II indicates the highest molecular solution, or fraction of molecular solution, in which the zygotes and the mycelia would grow; while the second column shows the same in terms of per cent of the chemical in solution. Column three gives the highest molecular solution in which a vigorous growth took place, the last column indicating the same thing in per cent of the chemical in solution.

TABLE II.

	Highest Concentration in which Growth Occurred.		Highest Concentration in which a Vigorous Growth Occurred.	
	Mol. Sol.	% Sol.	Mol. Sol.	% Sol.
NaCl	Mol.	5.48%	M/10	.548%
Fe_2Cl_6 $12H_2O$	M/11	1.2%	M/15	.808%
$CuSO_4$	M/70	.213%	M/150	.0994%
C_2H_5OH	3M+	13.8%+	2M	9.2%

Discussion.

It has been generally thought that zygote material of Mucor would not retain the power of germination for more than one year, but the first experiment demonstrated that they retained this power for at least two years, one year of which they were entirely without moisture. Since this is the case one might expect to find the zygotes in the air for a longer period than that.

When heat was added as a factor, a remarkable power of resistance was still shown. How long the zygotes would be able to resist the sixty (60) degrees centigrade in a desiccator remains to be seen, as five (5) weeks was the longest period tried. When the temperature was raised to seventy (70) degrees centigrade the old zygotes showed the lesser resistance, not being able to withstand the heat for as long a period as the newly matured ones.

When the temperature was seventy (70) degrees centigrade the inoculated oven-dried bread resisted to the same extent as those in the desiccator, though when the temperature was sixty (60) degrees centigrade the inoculated oven-dried bread was not able to stand the heat as long as the zygotes in the desiccator. How near it would come to it was not ascertained. The only explanation that the author can give is that the amount of moisture that would be present at sixty (60) degrees centigrade in the oven would be sufficient to be detrimental to the zygotes.

Those experiments in which the zygotes were placed upon oven-dried bread in an oven at one hundred (100) degrees centigrade would have practically the same degree of desiccation as the three experiments that were placed in the desiccators. In this experiment there is shown the most remarkable case of resistance, twenty-five (25) minutes in this heat not being sufficient to kill the zygotes; but another interesting fact is brought out, that being, that the ability of the mucor to produce zygotes is gone from those cultures remaining in the heat over 17½ minutes.

According to the present understanding of the formation of zygotes, there must be what is termed "two strains." By the term "strain" the author means not different varieties, but what in higher plants would probably be called male and female plants. In other words, there is a differentiation of mycelial threads, the union of the two (2) being

TABLE III.

	20°C.	40°C.	45°C.	50°C.	55°C.	60°C.	65°C.	70°C.	100°C.
1 year zygotes in desiccator	(524,160) 1 yr.					(50,400) 5 wks.+		(10,080) 1 wk.	
New zygotes in desiccator	(524,160) 1 yr.+					(50,400) 5 wks.+		(20,160) 2 wks.	
1 year zygotes on oven-dried bread						(10,080) 1 wk.+		(10,080) 1 wk.	
New zygotes on oven-dried bread						(20,160) 2 wks.+		(20,160) 2 wks.	(25) 25 min.
1 year zygotes on moist bread		(45) 45+ min.	(30) 30+ min.	(10) 10 min.	(4) 4 min.	(2) 2 min.	(1) 1 min.	(0) 0 min.	(0) 0 min.
New zygotes on moist bread		(45) 45+ min.	(30) 30+ min.	(15) 15 min.	(10) 10 min.	(5) 5 min.	(3) 3 min.	(0) 0 min.	(0) 0 min.

NOTE.—The numbers within the parenthesis indicate the relationship between the various experiments as to the endurance in the heat and the desiccation.

necessary for the formation of the zygote. If this is the case, then one of the "strains" must be weaker than the other and killed out by the unfavorable conditions, since zygotes were not formed in those cultures that had remained in the one hundred (100) centigrade heat for more than 17½ minutes.

The difference in the resistance between the old and the new zygote material in this set of experiments was not ascertained, as only the new was used.

When moisture was added as a factor, even when the amount was small, the resistance of the zygotes to the heat declined rapidly. With the amount of moisture ordinarily found in bread it was found to be sufficient to kill the zygotes in less than forty-eight (48) hours, when the temperature was raised to seventy (70) degrees centigrade, the time probably being only a matter of minutes as can be seen from comparing the results of the different experiments as shown in Table III.

In case there was a large amount of moisture there was a very great dropping off of the power of resistance and also a marked difference in the resistant power of the old and the newly matured zygotes. The rapid decline is when the temperature reaches fifty (50) degrees centigrade. How long the zygotes would resist the temperature of forty-five (45) and forty (40) degrees centigrade was not ascertained.

From a general survey of all the experiments (See Table III) it will be seen that the zygotes are able to withstand a large amount of heat as long as no moisture is present; but the addition of only a slight amount causes the resistant power to fall off very rapidly. Also the factor of dessication is a very small factor, if any, in the lowering of the vitality of the zygote. On the other hand it is a decided factor in increasing the power of resistance to heat.

If, then, one wishes to kill mucor, the surest way to do so is to use heat and moisture, not much heat being necessary in this case; while if moisture is not present a high temperature and a long application will be required.

To Dr. F. M. Andrews of Indiana University, I wish to express my appreciation for the encouragement and assistance given during the progress of the work. The author also wishes to express her appreciation for the help that Miss Flora Anderson rendered in completing some cf the experiments.

The Absorption of Iron by Platinum Crucibles in Clay Fusions.

W. M. Blanchard and Roscoe Theibert—DePauw University.

A short time ago on making a number of clay analyses, we were surprised at the persistent gain in weight of our platinum crucibles and the repeated appearance of ferric oxide after reheating a crucible that had been used in making a fusion. No note of such phenomena could be found in the standard treatises on analytical chemistry at hand, no mention of the absorption of iron by platinum being mentioned by Fresenius, Treadwell and Hall, Olsen, Morse, or Scott. The only mention of such action to be found in the literature available was in a paper by Sosman and Hostetter, Jour. Washington Academy, 5, 293-303, and only a synopsis as given in Chem. Abstracts, 9, 1580, was at hand. In this paper account is given of experiments made on the heating of hematite and magnetite in platinum crucibles at high temperatures, resulting in the absorption of iron and the loss of oxygen. The statement is made that it is a generally known fact that platinum crucibles will absorb small quantities of iron when heated to high temperatures with ferric oxide. In this synopsis in Chemical Abstracts no reference is made to any published data.

If a sample of ordinary clay is mixed with the usual amount of sodium carbonate and the mixture fused in the usual manner, the crucible will present the appearance of perfectly clean platinum when the product, on cooling, is removed by the treatment with hydrochloric acid. If this crucible is now heated for several minutes over the blast lamp or No. 3 Meeker burner, the lower third of the inside of the crucible will have an appearance varying from that of ordinary ferric oxide to that of certain bronzes. If strong hydrochloric acid is now added and the crucible heated gently, what appears to be a rather strong solution of ferric chloride is obtained. If this is removed, the crucible will have again the appearance of clean platinum, but, in many cases, when heated a second time, more iron will be driven to the surface and converted into ferric oxide. In some cases it has been found

necessary to subject the crucible to several successive heatings and treatment with strong hydrochloric acid in order to remove all of the iron absobed in a single fusion.

In order to determine whether this amount of iron is what might be considered merely a "trace" or whether it is sufficient to make an appreciable difference in the results of a quantitative analysis, several determinations were made. A platinum crucible was heated to constant weight after it had been subjected a number of times to the treatment just mentioned. A clay fusion was then made and the product removed by the aid of 20 per cent hydrochloric acid. The heating and treatment with the acid was then repeated until no further change was observed. The combined solutions of ferric chloride was reduced with stannous chloride, excess of mercuric chloride added, and the amount of iron determined by means of a standard solution of potassium dichromate. Some of the results obtained are as follows:

Weight of platinum crucible (from previous fusion) after successive heatings over an ordinary burner:

25.0089 25.0089 25.0090 25.0089

Same crucible after successive heatings of fifteen minutes each over a Meeker burner:

25.0097 25.0097 25.0095 25.0097

After treatment with the acid and complete removal of the iron:

25.0089 25.0090 25.0090 25.0089 25.0089

A fusion of a mixture of 0.5 gram of clay and 2.5 grams of sodium carbonate was then made and the product removed by the aid of the acid. Successive heatings over the Meeker burner, each followed by removal of the iron present, left the crucible weighing as follows:

25.0099 25.0097 25.0099 25.0103

After removal of the iron successive heatings gave

25.0089 25.0084 25.0088

After further treatment with the acid and successive heatings, the weights ran as follows:

25.0084 25.0083 25.0084 25.0081 25.0081 25.0082

The total amount of iron oxide found by titration with the potassium dichromate was 0.00459 gram.

After a third fusion, removal of the product, and heating over the Meeker burner the crucible weighed

25.0097 25.0098

After removal of the ferric oxide and reheating,

25.0080 25.0080 25.0080 25.0080

Amount of ferric oxide by titration, 0.0063 gram.

After a fourth fusion, removal of fusion product, successive heatings gave

25.0103 25.0100 25.0100

After removal of the iron oxide,

25.0085 25.0085

Total amount of ferric oxide by titration, 0.0051.

It seems that in fusing the clay and sodium carbonate mixture a very small amount the ferric oxide formed, or the ferrous oxide present is reduced, the iron dissolving in the platinum. When the crucible is afterwards heated to a high temperature, the iron is driven to the surface and reoxidized, thereby becoming soluble in the acid.

It was thought that this might be prevented by adding a small amount of potassium nitrate to the fusion mixture before making the fusion. A few experiments were made to test this hypothesis.

Weight of the crucible before fusion, 25.0079.

To the mixture of 0.5 gram clay and 2.5 grams sodium carbonate was added 0.3 gram pure potassium nitrate, the fusion made and the product removed in the usual way. The crucible was then heated eight times, fifteen minutes each, and weighed after each heating, the ferric oxide being removed before the succeeding heating. The weights were as follows:

25.0104 25.0103 25.0103 25.0103 25.0091 25.0087 25.0079 25.0079

The total amount of ferric oxide obtained by titration, 0.0021 gram.

A second fusion with the addition of 0.5 gram of potassium nitrate brought the weights of the crucible to the following:

25.0125 25.0122 25.0121 25.0120 25.0120 25.0120

The total amount of ferric oxide by titration, 0.0015 gram.

A third fusion, using again 0.5 gram of potassium nitrate resulted in the following weights:

25.0154 25.0152 25.0149 25.0149 25.0149 25.0149

No ferric oxide was detected by titration although a trace of ferric oxide was observed in the crucible.

A fourth trial with 0.5 gram of the nitrate resulted as follows:

25.0182 25.0181 25.0181 25.0178 25.0170 25.0165 25.0165

Total amount of ferric oxide by titration, 0.0025 gram.

It will be seen that the amount of iron absorbed by the crucible is sufficient to be taken into account in making an accurate analysis. In other words, after making a clay fusion, the crucible should be heated to a high temperature and the ferric oxide formed dissolved out and added to the vessel containing the main fusion product. Furthermore, it is seen that treatment with potassium nitrate is not a satisfactory way of avoiding the trouble, for while it does prevent the absorption of the iron to a large degree, it is the means of introducing other foreign substances into the crucible which may prove undesirable.

That this absorption of iron is not a peculiarity of this particular crucible, due to the presence of some other metal alloyed with the platinum, would seem to be indicated by the fact that the same phenomenon was observed in connection with two other crucibles purchased at different times and from different dealers; that it was not due to some unusual property of this particular clay is evidenced by the fact that the same thing occurred with clays obtained from widely different sections of the State.

A further study of this behavior is in progress.

Since the above paper was submitted for publication, the chief cause of the phenomena described has been discovered. The crucibles in which the fusions were made were heated over Meeker burners. In order that they might be heated to the highest temperature obtainable from these burners the crucibles were supported just above the top of the burners. As a result they were more or less enveloped in an atmosphere of reducing gases and it was due to these gases rather than to the organic matter in the clay that the iron was brought to a condition to be absorbed by the platinum. When these fusions are made with a good blast

lamp directed upon the crucible at a considerable angle, practically no iron is afterwards found in the platinum. It is probably because these burners have not generally been used for this purpose that this phenomenon has not been observed by others. It is clear that the Meeker burner is not a satisfactory substitute for the blast lamp in making fusions of clays or silicates that contain appreciable amounts of iron.

The Injurious Effect of Borax in Fertilizers on Corn.

S. D. Conner—Purdue University.

About June 1, 1917, the Experiment Station was notified that in a large number of fields near Francesville the young growing corn had lost its green color and had turned white or had entirely wilted down. Together with Mr. O. S. Roberts of the State Chemist's Department, I visited the cornfields on June 5th. We found a number of fields where the corn was entirely white. The damage was all on land where fertilizer was used, and by far the greatest damage was caused where fertilizer containing 5 per cent of potash and 5 per cent of available phosphoric acid had been used. There appeared to be no question about the fertilizer having caused the damage as in a number of fields one or more rows of unfertilized corn remained good alongside of badly damaged fertilized corn. In some fields several amounts of fertilizer had been used and the damage was greatest where the largest amounts of fertilizer were used. The fertilizer injured the corn by retarding germination, also by turning the corn white and holding it back so that insect damage was greater where the corn was fertilized, and in some cases the corn had even been killed. Some of the corn which was not damaged very badly was said by the farmers to be looking better than it had a few days before. Later reports indicate that some of the white corn recovered almost entirely while other fields had to be replanted, while still other fields remained more or less damaged even to time of harvest.

On September 24th another visit was made to the damaged fields. Some of the corn had been permanently damaged probably seventy per cent., other fields much less and in some cases there was no apparent damage. The damage seemed to vary on different types of soil, some of the worst was on light sandy and some on peaty soils. As a rule there was not so much damage on heavier soils. Corn fertilizer in Indiana is generally drilled along the row where the corn is checked or drilled. Fifty pounds of the 5-5 fertilizer per acre seldom caused much damage, while 200 pounds to the acre nearly always caused great

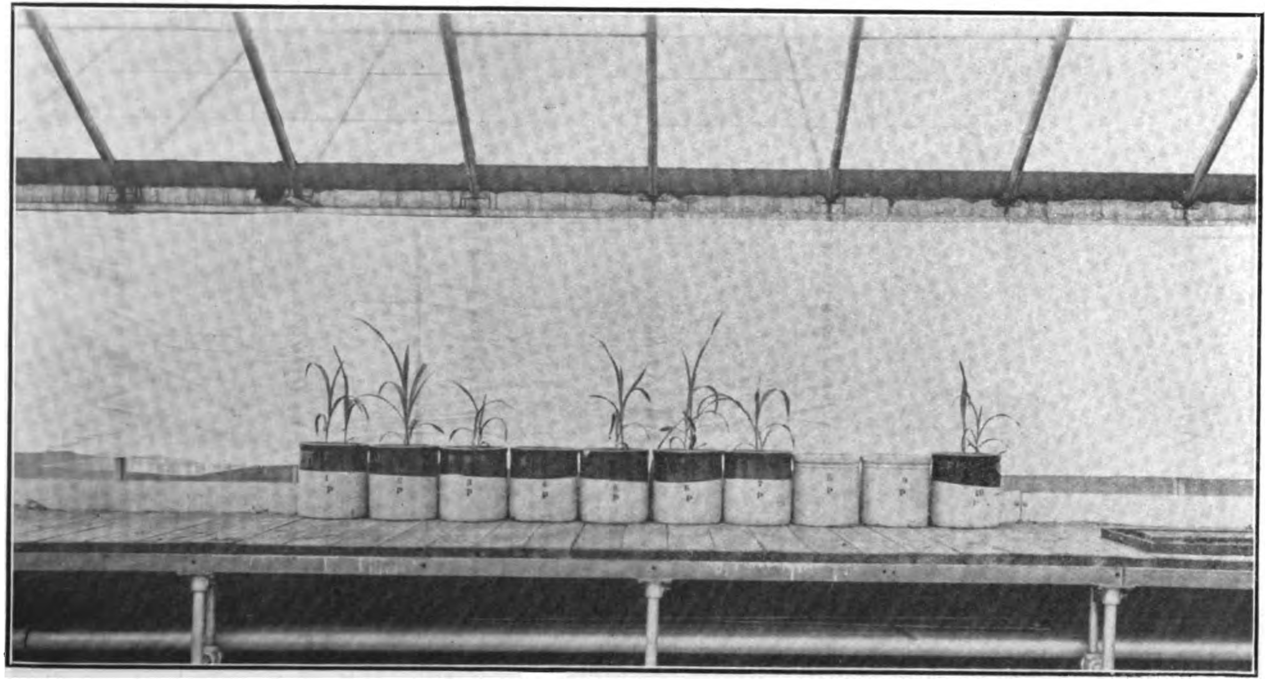


Fig. 1. Borax test with fertilizer on corn, Purdue soil.

Fig. 2. Borax test with fertilizer on corn, Francesville soil.

damage. Some farmers seemed to think that a fertilizer attachment with a spreader was better than an attachment that placed the fertilizer directly on the seed. Differences in amount of injury were undoubtedly caused by the different weather conditions, such as rain either just before or after planting.

All farmers who had used fertilizer which caused damage to the corn and who made complaint have been compensated by the fertilizer company selling the goods. The amount of damage was mutually agreed upon by the farmer and a representative of the fertilizer company with O. S. Roberts, Chief Inspector of the State Chemist's Department of the Experiment Station, acting as a disinterested referee.

Experimental Work.

To find the cause of the damage, the writer secured a sample of the 5-5 fertilizer which produced damage in one of the fields. Upon analysis this sample was found to contain 2.35 per cent boric acid (H_3BO_3) equivalent to 1.92 per cent borax ($Na_2B_4O_7$) soluble in water. Borax is an ingredient not usually found in fertilizer. It has been found by other investigators to be harmful when used in very large amounts.[1]

With the assumption that borax might be the harmful ingredient, quantities of soil were obtained from the field near Francesville damaged by the particular sample of 5-5 fertilizer analyzed; also soil from the Experiment Station farm. The Francesville soil is a black sandy loam neutral in reaction. The Purdue soil is brown silt loam, acid in reaction. Ten earthenware pots were filled with each type of soil and fertilizer applied as follows:

Pot. No.

1. No treatment.
2. 50 lbs. per acre in row of 5-5 fertilizer sold.
3. 100 lbs. per acre in row of 5-5 fertilizer sold.
4. 200 lbs. per acre in row of 5-5 fertilizer sold.
5. 200 lbs per acre broadcast of 5-5 fertilizer sold.
6. 100 lbs. per acre in row 5-5 fertilizer made in laboratory. No borax.

[1] Cook, T. C. and Wilson, J. B. in Jour. Agr. Res., Vol. X, No. 12, 1917; also Nakamura in Bul. Col. Agr., Tokyo, 1903; also Voelcker in Jour. Roy. Agr. Soc., Vol. 76, 1915.

7. 200 lbs. Same as No. 6.
8. 100 lbs. per acre in row of 5-5 fert. made in laboratory with 2 per cent borax.
9. 200 lbs. Same as No. 8.
10. 200 lbs. per acre broadcast 5-5 fert. made in laboratory with 2 per cent borax.

Where the fertilizer was applied in the row, the soil was furrowed out and the fertilizer applied, then the corn dropped in the same furrow and covered. The broadcast application was worked in the entire surface of the pot two inches deep. Corn was planted October 8, 1917, and the pots were kept uniformly watered in a greenhouse.

The notes in Table I indicate the results on the test up to January 1, 1918. Figures 1 and 2 show the appearance of the corn November 26th.

The results obtained in this pot test show that without doubt the commercial 5-5 fertilizer containing 1.92 per cent borax will injure corn if applied in the row 100 lbs. or more to the acre. Fifty pounds to the acre caused no damage.

The damage is caused by preventing germination, by bleaching the leaves of the young corn and by stunting or killing the young plant. This injury is identical to that which was noted in the field.

A 5-5 fertilizer made from kainit and acid phosphate did not bleach leaves or kill the plants when used 100 or 200 pounds in the row. In the 200 lb. application, this fertilizer caused some temporary stunting which later disappeared.

An artificial 5-5 fertilizer with 2 per cent borax added caused bleaching and even worse damage than the commercial sample did.

When the fertilizer was applied 200 lbs. to the acre broadcast that containing borax caused a slight bleaching but no permanent injury.

There seems absolutely no question but that 2 per cent borax in a fertilizer when used 100 pounds to the acre in the row will bleach the leaves of the corn plant and cause more or less permanent injury.

Chemical Estimation of the Fertility of Soils in Fulton County, Indiana.

R. H. Carr and W. K. Gast—Purdue University.

During recent years there has been an effort on the part of many States to invoice their soils as to plant food content in addition to making the usual survey in order to classify them into types and series. This invoice is useful first to the farmer in pointing out any deficiencies or excesses in the soil's food supply, and second to the State in estimating the wealth, since this usually resides in the fertility of the soils. Usually only the plant food elements are determined which seem to be the most important or have the greatest influence in modifying crop yield. They are the following: total organic carbon, total nitrogen, total phosphorus, total potassium, total calcium, total inorganic carbon. The test for the last is made for the presence of limestone, the absence of which often indicates soil acidity. There are many factors other than plant food concerned in producing a crop on any piece of land, as rainfall, tillage, drainage, etc., but deficiencies in these can be determined often by observation. But a deficiency in the main chemical elements is not so easily estimated and is a matter of life or death to the plant.

Availability of Plant Food.

Much discussion has arisen over the availability of these plant foods even when analysis has shown plenty to be present. It is conceded, however, that it is possible to make two per cent of total nitrogen, one per cent of phosphorus and one-fourth of one per cent of potassium available in one year by approved agriculture methods. If this were true, or somewhere near true, it would make a big difference in the crop yield to be expected whether there were 500 or 5,000 lbs. of phosphorus or nitrogen, etc., present per acre to a depth of six and two-thirds inches.

Plant Foods Present in a Good Soil.

It is difficult to set a definite standard of plant food content, but if we choose samples of our productive loam soils frequently producing

75 bushels of corn per acre, we find a plant food content about as follows:

POUNDS OF PLANT FOOD PER 2,000,000 POUNDS OF SURFACE SOIL.

Nitrogen 4,500 lbs., 2 per cent possible available in 1 year...... 90 lbs.
Phosphorus 1,500 lbs. (too low), 1 per cent.................... 15 lbs.
Potassium 32,000 lbs., one-fourth of one per cent.............. 80 lbs.
Organic matter, 160,500 lbs.
Limestone present, 350 lbs.

A 50-bushel corn crop would need about 74 lbs. of nitrogen, 11.5 lbs. of phosphorus and 35.5 lbs. of potassium in addition to the other essential elements usually present, and this amount of plant food could more than be supplied in a soil like the above.

PLAN OF INVOICING FULTON COUNTY SOILS.

The soil samples chosen numbered 128 and they were collected from the eight townships. Most of the soil samples were taken from surface soil (7 ins. deep), but 38 were from subsoils (6 to 20 ins.). Twenty of the samples were from virgin soil and represent more or less the original fertility of the soil unchanged by cropping. Many items were noted while the samples were being collected (August, 1916) or information was secured from the people living on the farms as to the prevalent weeds, stand of clover, kinds of timber, grain yield per acre, use of fertilizers and manures, etc. The following determinations were made on the soil samples: first, total organic matter; second, total nitrogen; third, total phosphorus; fourth, presence of carbonates and acidity to litmus. An attempt was made to correlate this data with the yield of corn per acre. It was thought this could be done best by means of graphs. Since the presence or absence of organic matter is so vitally related to crop yield, the soils were grouped into eight series depending on the amount of organic matter present in the soil. The samples are numbered as follows:

Richland Twp., 1-10 and 108-111, inclusive.
Aubbeenaubbee, 11-19 and 106-107.
Henry, 20-24 and 124-128.
Newcastle, 25-27 and 112-123.

Rochester, 28-31 and 45-60 also 66.
Liberty, 61-65 and 67-75.
Wayne, 76-87 and 91-93.
Union, 80-90 and 94-105.

The tables and graphs which follow will give a partial composition of the soil in per cents and pounds per acre and express this in terms of bushels of corn per yield.

TABLE I.

The N. P. and Organic Matter, from 0.5 to 1% Organic Matter.

	Sample No.	% O. M.	Pounds per Acre.	% N.	Pounds per Acre	% P.	Pounds per Acre.
1	9 Subsoil	.5143	10,286	.014	280	.0243	486
2	116 Subsoil	.6664	13,328	.017	340	.0462	924
3	87 Subsoil	.6789	13,578	.015	300	.0725	1,450
4	103 Subsoil	.7945	15,890	.0042	84	.0576	1,152
5	16 Subsoil	.8014	16,028	.014	280	.0674	1,348
6	*68 Subsoil	.8046	16,092	.027	540	.0364	728
7	2 Subsoil	.8614	17,228	.0084	168	.0553	1,106
8	79 Subsoil	.9824	19,648	.021	420	.0580	1,160

*Acid.

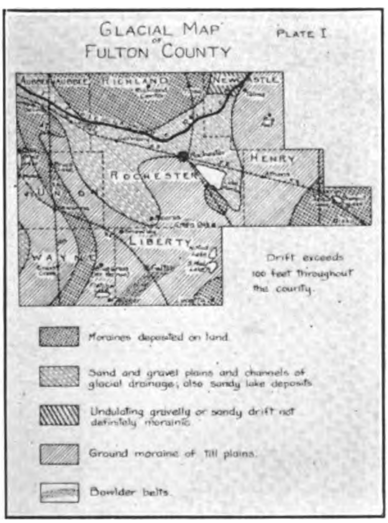


TABLE II.

The N. P. and Organic Matter, from 1 to 2% Organic Matter.

	Sample No.	% O. M.	Pounds per Acre.	% N.	Pounds per Acre.	% P.	Pounds per Acre.
1	12 Subsoil	1.141	22,820	025	500	.0320	640
2	98 Subsoil	1.158	23,160	.015	300	0539	1,078
3	5 Subsoil	1.171	23,420	.018	360	.0381	762
4	*33 Subsoil	1.233	24,460	.011	220	.0324	648
5	*96 Subsoil	1.318	26,360	.043	860	.0677	1,354
6	*55 Subsoil	1.376	27,520	.046	920	.1072	2,144
7	70 Subsoil	1.389	27,780	.017	340	.0755	1,510
8	89 Surface	1.396	27,920	.018	360	.0239	478
9	*110 Surface	1.397	27,940	.029	580	.0694	1,388
10	77 Subsoil	1.404	28,080	.027	540	.0674	1,348
11	*104 Virgin	1.472	29,440	.034	680	.0485	970
12	*61 Surface	1.576	31,520	.029	580	.0398	796
13	57 Subsoil	1.646	32,920	.014	280	.0516	1,032
14	*11 Surface	1.711	34,330	.059	1,180	.0526	1,052
15	67 Surface	1.744	34,880	.041	820	.0644	1,288
16	48 Surface	1.814	36,280	.066	1,320	.0768	1,536
17	*47 Surface	1.844	36,880	.063	1,260	.0256	512
18	*50 Virgin	1.902	38,040	.053	1,060	.0310	620
19	*102 Surface	1.992	39,840	050	1,000	.0465	930
20	*86 Surface	1.997	39,940	.050	1,000	.0613	1,226

*Acid.

12.2% of Surface Soils in this organic group.

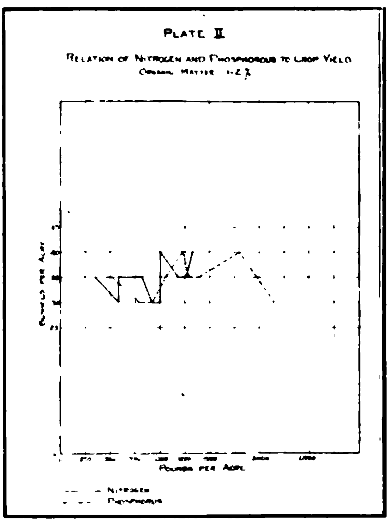


TABLE III.

The N. P. and Organic Matter, from 2 to 3% Organic Matter.

	Sample No.	% O. M.	Pounds per Acre.	% N.	Pounds per Acre.	% P.	Pounds per Acre.
1	*60 Subsoil	2.023	40,460	.018	960	.0745	1,490
2	*97 Surface	2.063	41,260	.069	1,380	.0559	1,118
3	*64 Subsoil	2.065	42,300	.021	420	.1543	3,086
4	*76 Surface	2.073	41,460	.056	1,120	.1180	2,360
5	*1 Surface	2.114	42,280	.063	1,260	.0273	546
6	*115 Surface	2.197	43,940	.083	1,660	.0182	364
7	*63 Surface	2.198	43,960	.053	1,060	.0411	822
8	*107 Surface	2.245	44,900	.067	1,340	.0816	1,632
9	†13 Virgin	2.307	46,140	.063	1,260	.0654	1,308
10	*21 Subsoil	2.394	47,880	.032	640	.0762	1,524
11	†29 Subsoil	2.403	8,060	.022	440	.0162	324
12	*56 Surface	2.422	48,440	.077	1,540	.0634	1,268
13	*31 Surface	2.442	48,840	.032	1,240	.0580	1,160
14	*75 Surface	2.475	49,500	.038	760	.1031	2,062
15	*99 Virgin	2.526	50,520	.070	1,400	.1031	2,062
16	*90 Subsoil	2.564	51,280	.055	1,100	.0738	1,476
17	* Surface	2.567	51,340	.070	1,400	.0849	1,698
18	*32 Surface	2.579	51,580	.064	1,280	.0479	958
19	51 Surface	2.585	51,700	.076	1,520	.0499	998
20	*4 Surface	2.620	52,400	.081	1,620	.0580	1,160
21	19 Subsoil	2.679	53,580	.036	720	.0394	788
22	65 Virgin	2.722	54,440	.059	1,180	.0600	1,200
23	†58 Virgin	2.798	55,960	039	780	.0620	1,240
24	*105 Surface	2.841	56,820	.011	220	.0229	458
25	*111 Virgin	2.886	57,720	.076	1,520	.1092	2,184
26	95 Surface	2.935	58,700	.125	2,500	.0644	1,288
27	*6 Virgin	2.994	59,880	.076	1,520	.0519	1,038

*Acid. †Very acid.

23.3% of Surface Soils in this organic group.

PLATE III.

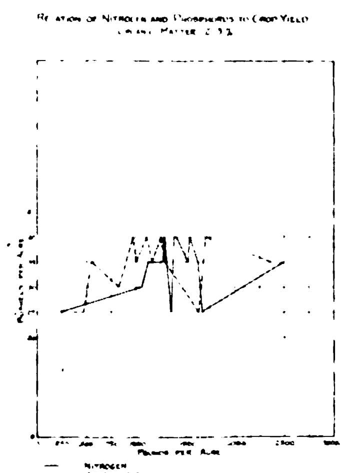


TABLE IV.

The N. P. and Organic Matter, from 3 to 4% Organic Matter.

	Sample No.	% O. M.	Pounds per Acre.	% N.	Pounds per Acre.	% P.	Pounds per Acre.
1	*69 Surface	3.000	60,000	.085	1,700	.0576	1,152
2	34 Virgin	3.006	60,120	.085	1,700	.0843	1,686
3	118 Subsoil	3.101	62,020	.080	1,600	.0708	1,416
4	*43 Surface	3.131	62,620	.083	1,660	.0718	1,436
5	9 Subsoil	3.164	62,280	.032	640	.0414	828
6	*28 Surface	3.170	63,400	.070	1,400	.0634	1,268
7	52 Subsoil	3.176	63,520	.028	560	.0209	418
8	37 Surface	3.202	64,040	.090	1,800	.0516	1,032
9	122 Surface	3.228	65,160	.118	2,360	.0738	1,476
10	*62 Surface	3.258	65,360	.102	2,040	.0839	1,678
11	*10 Virgin	3.291	65,820	.074	1,480	.0401	802
12	92 Subsoil	3.338	66,760	.062	1,240	.0445	890
13	*42 Surface	3.405	68,100	.111	2,220	.0704	1,408
14	123 Subsoil	3.433	68,660	.078	1,560	.0623	1,246
15	74 Surface	3.489	69,780	.105	2,100	.0462	924
16	*8 Surface	3.589	71,790	.101	2,020	.0516	1,032
17	*14 Surface	3.837	76,740	.111	2,220	.0630	1,260
18	*7 Surface	3.861	77,220	.106	2,120	.0741	1,482
19	*38 Surface	3.905	78,100	.104	2,080	.0775	1,550
20	46 Subsoil	3.912	78,240	.062	1,240	.1132	2,264
21	*15 Surface	3.913	78,260	.143	2,860	.0593	1,186

*Acid.

16.6% of Surface Soils in this organic group.

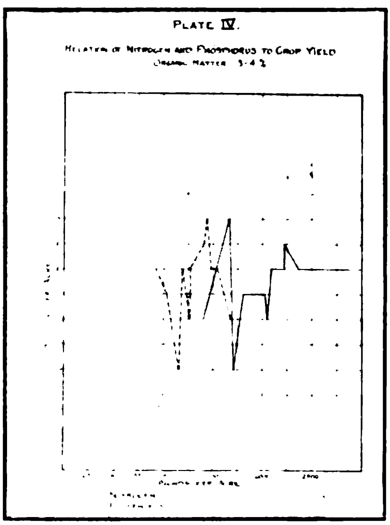


TABLE V.

The N. P. and Organic Matter, from 4 to 6% Organic Matter.

	Sample No.	% O. M	Pounds per Acre.	% N.	Pounds per Acre.	% P.	Pounds per Acre.
1	80 Virgin	4.010	80,200	.109	2,180	.0812	1,624
2	†20 Surface	4.057	81,140	.113	2,260	.0593	1,186
3	*17 Virgin	4.119	82,380	.118	2,360	.0937	1,874
4	128 Virgin	4.233	84,660	.099	1,980	.1014	2,028
5	*66 Surface	4.299	85,980	.146	2,920	.1078	2,156
6	109 Surface	4.473	89,460	.133	2,660	.0317	634
7	*83 Surface	4.547	90,940	.120	2,400	.0600	1,200
8	91 Surface	4.833	96,660	.140	2,800	0846	1,692
9	126 Surface	4.892	97,840	.112	2,240	.1001	2,002
10	*85 Surface	4.901	98,020	.164	3,280	.1099	2,198
11	100 Surface	5.130	102,600	.157	3,140	.0620	1,240
12	27 Subsoil	5.334	106,680	.0084	168	.0101	202
13	*59 Surface	5.335	106,700	.176	3,520	.0752	1,504
14	*93 Virgin	5.451	109,020	.175	3,500	.0866	1,732
15	127 Subsoil	5.504	110,080	.077	1,540	.2123	4,246
16	78 Surface	5.579	111,580	.090	1,800	.0647	1,294
17	119 Virgin	5.703	114,060	.220	4,400	.1479	2,958
18	125 Subsoil	5.833	116,660	.108	2,160	.0696	1,392
19	*30 Virgin	5.996	119,920	.169	3,380	.0010	1,820

*Acid. †Very acid.
17.7% of Surface Soils in this organic group.

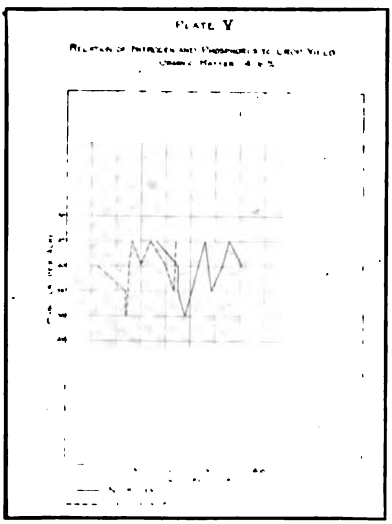


TABLE VI.

The N. P. and Organic Matter, from 6 to 10% Organic Matter.

	Sample No.	% O. M	Pounds per Acre.	% N.	Pounds per Acre.	% P.	Pounds per Acre.
1	117 Surface	6.278	125,560	.195	3,900	.0667	1,334
2	113 Subsoil	6.462	129,240	.192	3,840	.0654	1,308
3	73 Virgin	6.737	134,740	.190	3,800	.1382	2,764
4	72 Subsoil	7.215	144,300	.167	3,340	.0317	634
5	114 Virgin	7.437	148,740	.258	5,160	.1533	3,066
6	108 Surface	7.603	152,060	.020	400	.1412	2,824
7	112 Surface	8.645	172,900	.307	6,140	.1587	3,174
8	18 Surface	8.695	173,900	.245	4,900	0108	216
9	94 Surface	9.312	186,240	.076	1,520	.0559	1,118
10	23 Subsoil	9.377	187,540	.227	4,540	.1031	2,062
11	26 Surface	9.634	192,680	.274	5,480	.1122	2,244
12	45 Surface	9.836	196,720	.295	5,900	.1692	3,384

10% of Surface Soils in this organic group.

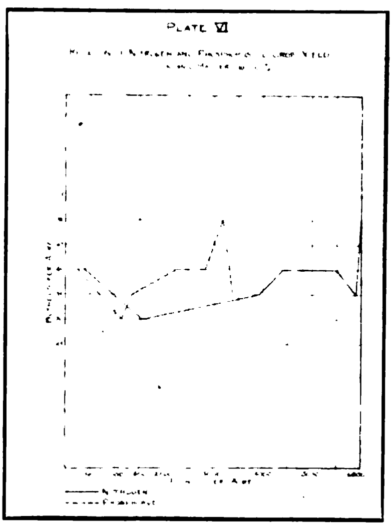


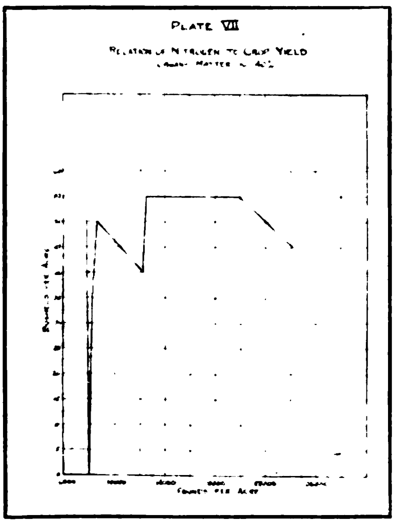
TABLE VII.

The N. P. and Organic Matter, from 10 to 40% Organic Matter.

	Sample No.	% O. M.	Pounds per Acre.	% N.	Pounds per Acre.	% P.	Pounds per Acre.
1	25 Surface	11.205	224,100	.409	8,180	1361	2,722
2	24 Virgin	11.891	237,820	.403	8,060	.1227	2,454
3	121 Surface	12.009	240,190	.399	7,980	.0344	688
4	82 Surface	12.025	240,500	.000	0 000	.1301	2,602
5	*71 Surface	13.146	262,920	.391	7,820	.0839	1,678
6	22 Surface	13.228	264,560	.428	8,560	.0816	1,632
7	84 Surface	16.318	326,360	.610	12,200	.1752	3,504
8	81 Surface	20.026	400,520	.626	12,520	.2763	5,526
9	39 Surface	28.239	564,780	.994	19,880	.1995	3,990
10	101 Surface	23.230	664,600	1.205	24,100	.3936	7,872

*Acid.

11.1% of Surface Soils in this organic group.



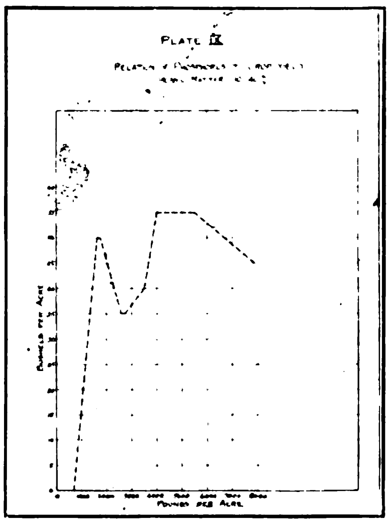


TABLE VIII.

The N. P. and Organic Matter, from 40 to 85% Organic Matter.

	Sample No.	% O. M.	Pounds per Acre.	% N.	Pounds per Acre.	% P.	Pounds per Acre.
1	*120 Surface	41.666	416,660	1.491	14,910	.0903	903
2	41 Virgin	51.778	517,780	1.529	15,290	.2258	2,258
3	*36 Subsoil	56.469	564,690	1.876	18,760	.2642	2,642
4	†44 Surface	64.652	646,520	2.138	21,380	.2116	2,116
5	124 Surface	66.196	661,960	2.124	21,240	.2035	2,035
6	†35 Surface	68.514	685,140	2.254	22,540	.3060	3,060
7	106 Surface	72.343	723,430	2.656	26,560	.3923	3,923
8	53 Surface	76.913	769,130	3.276	32,760	.3572	3,572
9	54 Subsoil	80.661	806,610	3.157	31,570	.3478	3,478
10	40 Subsoil	81.260	812,600	1.928	19,280	.3977	3,977
11	88 Surface	84.698	846,980	2.496	24,960	.2912	2,912

*Acid. †Very acid. *1,000,000 pounds per acre 6 2-3 in. = weight of muck soil.
8.8% of the Surface Soils in this organic group.

SUMMARY.

Analysis shows that a large per cent of the soils of Fulton County are deficient in organic matter. About half of them are below 4 per cent.

The soils are not very acid to litmus. Only six samples were found to be unusually acid while fifty-two others were slightly acid to the same indicator. Most of the acid samples were among the soils containing a low amount of organic matter.

A considerable number of the soils contained less than 1,500 pounds of phosphorus and nitrogen per acre (6 2/3 in.). These amounts are deficient and such soils would undoubtedly respond profitably if fertilized with these elements.

The tables show a considerable decrease in content of plant food in cultivated soil compared with corresponding virgin soils.

The accompanying graphs indicate that there is a close relationship between the yield of corn and the nitrogen and phosphorus content of the soil. As the nitrogen and phosphorus content increases, the yield increases.

Sulphur By-Products of the Preparation of Ether.

P. N. Evans and G. K. Foresman—Purdue University.

The formation of ethyl ether from alcohol and sulphuric acid was first explained by Williamson in 1852. According to his theory the first reaction is the formation of ethyl sulphuric acid and water, according to the equation,

$$C_2H_5OH + H_2SO_4 = C_2H_5HSO_4 + H_2O.$$

The ethyl sulphuric acid then reacts with more alcohol to form ether and sulphuric acid,

$$C_2H_5HSO_4 + C_2H_5OH = C_2H_5OC_2H_5 + H_2SO_4.$$

If these changes were the only ones taking place a limited quantity of sulphuric acid might convert an unlimited quantity of alcohol into ether and water.

Experience has shown, however, that there is a limit to the quantity of alcohol that can be converted into ether by a given weight of sulphuric acid, and two explanations have been offered for the limitation.

Many writers accept the theory that the water produced in the first reaction so dilutes the sulphuric acid that the change can not continue. It has been shown, however, by Evans and Sutton, that the water does not accumulate enough to prevent the reaction but distills over with the ether, normal results having been obtained when starting with very dilute sulphuric acid, the acid becoming concentrated enough for its normal effect by the time the proper temperature (140°) is reached.

Others, including the present writers, accept the explanation that the sulphuric acid employed is gradually converted into other sulphur compounds, either carried out of the generator with the ether and water, or, if remaining, incapable of inducing the formation of ether. The purpose of the work here reported was to determine the quantities of these sulphur by-products formed during the heating.

Numerous by-products have been reported by previous workers, including the following: Sulphur dioxide, sulphurous acid, ethyl sulphurous acid; sulphuric anhydride, ethyl sulphuric acid, ethyl sulphate;

ethyl sulphonic acid, isethionic acid, ethionic acid, butyl sulphonic acid and the ethyl esters of these acids.

Experimental.

Outline.

The experimental work consisted of the preparation of ether in the usual way from ordinary alcohol and strong sulphuric acid, maintaining as nearly as practicable a constant temperature of 140°, as long as ether resulted from introducing fresh alcohol. The distillate and residue were then examined quantitatively for by-products containing sulphur, which were determined as of three classes: sulphurous acid and sulphites, sulphuric acid and sulphates, and sulphonic acids and sulphonates; no distinction was made between the different possible substances within any class, as between the acid and its esters, except in the case of sulphuric acid and its esters.

Sulphuric Acid Used.

Twenty-five cubic centimeters of commercial concentrated acid were used, so-called 66° Baumé or 1.84 sp. gravity. Unfortunately an accurate determination of its concentration was not made, but assuming that the material used was in accordance with its specification it contained about 95 per cent H_2SO_4, and the weight of pure acid used was 43.7 grams. This figure agrees fairly well with the total sulphur found in the products, which was equivalent to 45.25 grams of sulphuric acid. The work is being repeated with accurate observations.

In the percentages given below reference is made to the total sulphur found by direct analysis of the products, and not this 43.7 grams of sulphuric acid.

Ether Preparation.

The apparatus included a 250 cc. distilling flask provided with a thermometer dipping into the liquid, and a dropping funnel delivering alcohol just above the surface and bent away from the thermometer; the flask was attached to a condenser, connected with a 2½ liter receiving bottle, followed by two wash-bottles containing bromine water, the entrance tube of each reaching to the bottom, to catch any possible sulphur dioxide escaping from the receiving bottle. Each bottle was provided with a safety tube reaching nearly to the bottom, which in

the case of the wash-bottles served also for the introduction of bromine as needed.

In the flask were placed 25 cc. concentrated sulphuric acid and 25 cc. ordinary strong alcohol, so-called 95 per cent; the mixture was heated to 140° and the temperature maintained as nearly constant as possible, alcohol being run in continuously from the funnel. The distillation lasted a total of 33½ hours exclusive of interruptions. Air was then aspirated through the whole apparatus to sweep out remaining vapors; a small quantity of black residue was left in the flask.

Examination of the Distillate.

The distillate measured 4,100 cc. from 4,700 cc. of alcohol used; it was acid to litmus and its gravity was 0.830 at 18°.

The apparent loss is due largely to the formation of ethylene, evidence of which was shown by a layer of ethylene bromide in the wash bottles.

One liter of the distillate was saponified with an excess of sodium hydroxide, to convert all esters into the corresponding sodium salts, and distilled down to 50 cc., the distillate being again distilled down to about 5 cc. and the residues were mixed. It was alkaline.

Sulphur as Sulphur Dioxide and Sulphites.

The alkaline residue was diluted and an aliquot part was acidified with hydrochloric acid and distilled into bromine water to convert the sulphur dioxide evolved into sulphuric acid, which was determined as barium sulphate; the sulphur found amounted to 1.03 per cent of that employed as sulphuric acid. The contents of the two wash-bottles containing bromine water were freed from bromine and precipitated with barium chloride and 0.96 per cent of the original sulphur found. During the preparation of ether, therefore, 1.99 per cent. of the sulphur of the acid used was lost from the generating flask in the form of sulphur dioxide and sulphites.

Sulphur as Sulphuric Acid and Sulphates.

An aliquot part of the alkaline residue from the saponification was analyzed for sulphates by precipitation as barium sulphate. The sulphur found amounted to 89.42 per cent of the total found.

In order to distinguish between sulphuric acid, ethyl sulphuric acid and ethyl sulphate in the ether distillate, the residue on evaporation of an aliquot part was dissolved in water and precipitated with barium chloride; the barium sulphate corresponded to 46.54 per cent of the total sulphur as sulphuric acid. The total acidity of another aliquot part of the residue of the ether distillate was determined by titration with standard alkali; the free sulphuric acid already found as described was subtracted, and the remaining acidity considered as due to ethyl sulphuric acid, the sulphur in this form amounting to 8.49 per cent of the total sulphur. The total sulphur in the ether distillate (89.42) less the sulphur as sulphuric acid (46.54) and that as ethyl sulphuric acid (8.49) would represent the sulphur as ethyl sulphate, namely, 34.39 per cent of the total sulphur.

As several months elapsed between the preparation of the ether and this examination of the product it is probable that there had been considerable change from ethyl sulphate into ethyl sulphuric acid and sulphuric acid, on account of the hydrolytic action of the water present. At the temperature of 140°, however, sulphuric acid (boiling point of the dihydrate is given as 170-199°) might distill as readily as ethyl sulphate (boiling point 208°); nothing seems to be known as to the possibility of ethyl sulphuric acid distilling as such.

Sulphur as Sulphonic Acids and Sulphonates.

The filtrate from the barium sulphate precipitate obtained in the determination of sulphur as sulphuric acid and sulphates was evaporated to dryness and the residue subjected to a Carius determination for sulphur; 4.62 per cent of the total sulphur was found.

Examination of the Residue.

Sulphur as Sulphur Dioxide.

The residue, weighing 3 grams, stood several months in the closed distilling flask. Air was aspirated through the flask and then through bromine water, and 0.15 per cent of the total sulphur was found in the bromine water.

Sulphur as Sulphuric Acid.

The residue was extracted with water and an aliquot part of the filtrate was treated with barium chloride; 1.69 per cent of the total sulphur was found.

Sulphur as Sulphates.

An aliquot part of the filtrate from the black residue was saponified with sodium hydroxide and total sulphuric acid determined as barium sulphate. Deducting the sulphuric acid found without saponification treatment, 0.99 per cent of the original sulphur was found as sulphates, presumably ethyl sulphuric acid and ethyl sulphate.

Sulphur as Sulphonic Acids and Sulphonates.

The filtrate from the barium sulphate obtained in the determination of sulphur as sulphates was evaporated to dryness with potassium nitrate and barium hydroxide, and the residue after ignition, was treated with dilute nitric acid, filtered and weighed as barium sulphate, showing 1.02 per cent of the original sulphur.

Sulphur in the Insoluble Carbonaceous Residue.

The extracted black residue was fused with potassium nitrate and barium hydroxide and the resulting barium sulphate was weighed. It corresponded to 0.12 per cent of the original sulphur.

Conclusions.

From the following results it appears that the formation of ether ceases because of the disappearance of the sulphuric acid from the generating flask.

Sulphur was found in the following forms and proportions, referred to their total as 100 per cent.

Sulphur dioxide escaping from the receiver during distillation		0.96 per cent.
Sulphur dioxide and sulphites in ether distillate		1.03
Sulphuric acid and sulphates in ether distillate		89.42
Sulphuric acid in ether distillate	46.54	
Ethyl sulphuric acid in distillate	8.49	
Ethyl sulphate in ether distillate	34.39	

Sulphonic acids and sulphonates in distillate..........	4.62
Sulphur dioxide in residue..........................	0.15
Sulphuric acid in residue............................	1.69
Ethyl sulphuric acid and ethyl sulphate in residue....	0.99
Sulphonic acids and sulphonates in residue............	1.02
Sulphur in insoluble carbonaceous residue............	0.12
Total	100.00

The Effect of Tobacco Smoke and of Methyl Iodide Vapor on the Growth of Certain Micro-Organisms.

(Abstract. Published in full in Am. Jour. Bot. 5: 1918.)

C. A. Ludwig—Lawrence University, Appleton, Wis.

The work here abstracted was carried out under the direction of Prof. F. C. Newcombe at the University of Michigan and was supplementary to a similar investigation in which illuminating[1] gas and its constituents were employed.

The organisms used in the case of tobacco smoke included 14 species of bacteria and 2 of fungi, and in that of methyl iodide vapor 13 species of bacteria and 2 of fungi. The cultures were on glucose nutrient agar slants. The culture chambers were tubulated glass bell jars set in crystallizing dishes and sealed with paraffin.

The methyl iodide was introduced into the chamber on a pledget of cotton attached to the end of a glass rod fastened in a stopper. The stopper, in turn, was used to close the tubulature in the bell jar.

When smoke was used it was introduced by means of a tube through a two-hole stopper in the tubulature. The suction was provided by an aspirator connected with the interior of the bell jar by a tube through the second hole in the stopper. The tobacco was burned in a cob pipe. In some tests the smoke was used without being treated in any way; in others it was passed through one or two wash bottles of water.

The results indicated that tobacco smoke is toxic to the organisms tested but not so extremely toxic as to some phanerogams. In view of the large number of compounds in smoke it is hardly worth while to venture an opinion as to what substances caused the results observed. The wash smoke, however, showed less toxicity than the unwashed smoke. This would suggest that something capable either of being condensed or of being dissolved in water has some part in causing the results.

The effect of methyl iodide vapor was to kill the cultures where the concentration was great enough. Where the concentration was less it resulted in an initial great retardation in the development of the streaks followed later by a very vigorous growth.

[1] The influence of illuminating gas and its constituents on certain bacteria and fungi. Am. Jour. Bot. 5: 1918.

Brief Notes on the New Castle Tornado.

C. C. Beals—Indiana University.

A number of destructive tornadoes occurred in Indiana during 1917. The first one of these passed over a part of New Castle. Mr. Melvin Kelleher and the writer mapped the tract of the storm under the direction of the Geology Department of Indiana University.

The New Castle tornado formed about 3:00 o'clock in the afternoon on March 11, 1917. At the point of origin objects were displaced by two currents of air. One from the southwest and the other from the northwest, meeting in Sec. 11, Tp. 17 N, R. 9 E. The wind from the southwest seemed to be a straight wind but the one from the northwest evidently had a spiral motion, judging from the direction the fences, trees and other objects fell. The first evidences of wind disturbance occurred about one mile southwest of Cadiz. The storm traveled almost due east except for a few short curves. It struck New Castle about the center on the west side, after crossing a broad glacial valley, and emerged near the southeast corner of the town. The tornado continued in a general eastward direction, going south of Hagerstown, and ceased inflicting damage about four miles southeast of that place.

The storm evidently continued eastward high in the air, going about eight miles north of Richmond into Ohio. Fragments of articles were found in Ohio.

One interesting feature noted was in a large wood about sixty rods from north to south which lay in the path of the wind where the storm first formed. Trees were uprooted and broken off, all falling toward the general direction of the wind except two trees at either end, which were crossed. The main destruction was caused by the portion of the storm south of the storm center and the crossing was produced by the opposite current in the whirl.

The track of the storm could be easily traced except at two points, where there was no disturbance for over one-half mile in each case.

The storm first appeared like a huge mass of black coal smoke

rolling, tumbling forward, which later formed a black cloud w
funnel-shaped tail. The noise made by it was described as being
hundred autos running at once.

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The most palpable objection to this view is the fact that no nonconformity exists between the Knobstone and the Harrodsburg limestone at their contact a few miles west of the strip. Another objection is that the bottom of the channel, at present at least, is not all of uniform elevation throughout its length. The principal objections to the view of a double fault are two—at no point was a direct vertical contact of Knobstone and limestone visible, nor was there to be seen any of the tilting, crushing and shattering which usually accompanies faulting. On the other hand, as the vicinity of the contact line is approached the shaly layers of the limestone become more and more argillaceous and apparently pass over into the Knobstone. To determine the exact conditions under which the limestone strip was laid down would require more extended study than is consistent with the scope of this report. What has been done was to trace upon the accompanying maps the outcrop of the Bedford oölitic and to examine the bed more carefully at places where it is now being quarried, namely at Heltonville and Fort Ritner."

In the proceedings of the Academy of Science of Indiana for 1897, page 262, J. A. Price discusses the boundary of the limestone strip and says in conclusion: "It is not possible, from data in hand, to say surely whether this strip of limestone owes its existence to an unconformity or a fault."

In 1903 J. F. Newsom published a description of a "Geologic Section Across Southern Indiana" as a part of the 26th Annual Report of the State Geologist. On pages 274 and 275 Newsom refers to the structure as a fault in the Knobstone area. He gives its extent as being from near Unionville in Monroe County to a point in the northern part of Washington County.

In referring to the discussions of Siebenthal and Price in the 27th Annual Report of the State Geologist, 1903, on page 90, Ashley says: "It is evident that if the limestone strip north of White River is due to a fault its effects should continue to the south rather than turn and follow the outcrop. A glance at the map in the region north of Campbellsburg is alone sufficient proof of the fault character of the disturbance."

In studying this structure in detail the writer has found that it is much more extensive than Newsom stated; that there is a second fault;

that other disturbances were connected with it and that the actual contact which he has found presents some interesting features.

Extent of the Fault.—While I have not yet been able to trace the fault to the borders of the State at either of its extremities I have been able to trace it far beyond its mentioned boundaries and feel confident that the particular disturbance under discussion extended from the Ohio to the Wabash along the western border of the Knobstone outcrop and perhaps beyond. Tracing the fault south of Campbellsburg in Washington County is difficult because the area on each side of the rift is occupied by limestone.

Along the northern end of the displacement glacial deposits conceal the bedrock to such an extent as to render observation difficult. Under these circumstances the best that can be done is to trace the disturbance by the reversal of dip of the limestones, as the finding of the rift will be extremely difficult. By such observations as it was possible to make I have traced the disturbance from a point southeast of Campbellsburg in Washington County to a point northwest of Waveland in Montgomery County.

Rift.—The actual contact of the rocks along the fault plane is revealed in only a few places. There are numerous places where the harder, more resistant stratum of limestone stands forth like a wall on one side of the rift, but the opposite side is occupied by mantle rock which was derived by the weathering of the Knobstone and which conceals the actual rift. Excavations made at such places would doubtless reveal the actual contact of the limestone and the Knobstone.

In a few localities the rift is exposed and the plane of the fault is bordered on the one side with limestone and on the other by shale. One outcrop of the rift zone was found in the bed of the north fork of Leatherwood Creek near Heltonville. At this point the Knobstone occurs on one side of the fault plane and the Harrodsburg limestone on the other. The line of rift is distinct, being marked by a thin bed of breccia. The brecciated zone is composed mainly of fragments of limestone in which small fragments of shale are intermingled. These fragments have been cemented together with calcite and the whole zone more or less marbleized. In a cross-section of the brecciated rock the veins of calcite stand out clearly, as they are whiter than the fragments of limestone and shale which they bind together. Small quantities of

other minerals are present in some parts of the brecciated zone, but there is an absence of the more insoluble minerals, such as silica or the silicates. This fact leads to the conclusion that meteoric rather than thermal waters have played the leading role in the concentration of these minerals.

Periods of Movement.—The question of whether the displacement took place all at one time or was intermittent is an interesting one. All of my attempts to find an evidence of intermittent movement by an examination of surface features have been unsuccessful. If there were intermittent movements of any considerable extent we would probably find them revealed in hanging valleys on the upthrow side and the rapid broadening of valleys on the downthrow side of the fault. In case there were two stages of movement, and the movement in the last stage an exceedingly slow one, the vertical cutting of the main stream might be as rapid as the uplift, but still the rejuvenation of the tributaries should result in a narrowing of the valleys. In the rift zone there is evidence of two stages of movement though the amount of displacement in the second stage is slight. The time interval between the two movements was of considerable length, since the fragments of the brecciated zone were firmly cemented before the second movement took place. Fragments of shale which were included in the limestone fragments during the first movement were faulted by the second movement. These shale inclusions would not have undergone faulting had they not been held rigidly in place by the cementing material.

Amount of Throw.—The amount of throw of the fault varies probably from 200 to 300 feet. Opportunities for measuring the amount of throw are not numerous. It can best be computed by estimating the total amount of eastward dip of the formations along the line of contact between the Harrodsburg and the Knobstone. At a point south of Mt. Carmel the difference in elevation of the contact above sea level is 50 feet in a distance of one-fourth mile. Since the width of the down-thrown block is at least one mile and a half in this locality the throw of the fault is at least 300 feet. The amount of dip of the down-thrown beds in other localities is less than at this point, so much less that the indicated throw is not more than 200 feet.

Age of the Fault.—The time at which the dislocation occurred can not be fixed definitely. It is probable that it occurred at the close of the

Paleozoic Era when the Appalachian revolution which resulted in the elevation of the eastern part of North America took place. Contemporaneous with or subsequent to that great epeirogenic movement, faulting and minor folding took place in Indiana, Illinois and Iowa, and other States lying as far west as these from the region of maximum disturbance. These faults like the one under discussion have a northwest trend.

The Heltonville Fault.—About one mile west of the Mt. Carmel fault there is a second fault. This I have named the Heltonville fault because the rift is exposed a short distance east of Heltonville in the bed of the north fork of Leatherwood Creek, at a point just east of the wagon crossing under the Southern Indiana railroad. This fault lies approximately parallel with the Mt. Carmel fault. The limestone has been faulted down against the Knobstone. Slickenslides have been produced in the limestone and it has been much fractured. In places the limestone has been thrust backward and fragments of the Knobstone shales have been thrust into the limestone. In places these formations are dovetailed, fingers of limestone projecting into the Knobstone and vice versa as first one and then the other yielded to the pressure. The fragments of limestone containing inclusions of shale have been united by calcite veins.

Though the fault character of the disturbance at this point is incontestable it is not equally clear at other points. The disturbance extends both north and south of this point, but it probably passes into a fold in both directions. In Monroe County near Unionville there is an anticline which occupies about the same position in relation to the Mt. Carmel fault as the Heltonville fault does. Similar folds have been noted at intervening points and also to the south of Heltonville.

Effect Upon Topography.—The general effect upon topographic conditions within the area of disturbance has been to produce a narrow limestone belt extending parallel with the main Knobstone outcrop and bordered on each side by outcrops of Knobstone. In the southern portion of the faulted area the western belt of Knobstone is absent, but its nearness to the surface along the line of the eastward reversal of dip is revealed in the channels of many streams which have carved their valleys at right angles to the line of reversal. Probably the most marked effect is on the drainage. Both surface and underground

drainage lines are affected. In the faulted area the ground waters which have found their way through the limestone have a tendency to follow the eastward sloping surface of the Knobstone to the rift, and near this point often come to the surface in a stream valley which lies near the rift and generally parallel with it. This tendency of the underground streams is modified by local dips of the strata north or south.

The surface streams, especially those along the line of the fault plane, have been influenced by the displacement. They have worked off the harder limestones on to the Knobstone in many places. These follow the line of rift until a local north or south dip has caused them to change the direction of their course. Small tributaries of the larger cross-cutting streams have developed, as has been noted again and again, along the line of rift.

Utilization of Indiana Kaolin.

William N. Logan—Indiana University.

Extensive beds of kaolin exist in Lawrence and Martin counties in the horizon of the Huron formation. The kaolin has been mined and utilized to a limited extent only. Its abundance and quality justifies a more extended use. Attempts have been made to use it as a substitute for southern kaolin used in Indiana in the manufacture of encaustic tile. The lack of bonding power is evident from the cracks and crazes which occur in the burned ware. The writer undertook to find a clay which might be mixed with the kaolin for the purpose of supplying bonding power and tensile strength. Mixtures of pottery clays and Indiana fire clays were made and the objects burned. It was found that tile could be manufactured successfully out of the kaolin when from 25 to 40 per cent of fire clay was added.

Certain Indicia of Dip in Rocks.

William N. Logan—Indiana University.

The object of this paper is to bring together certain indications of dip and the direction of dip in rocks which the writer has observed in his field work. All of these indicia have been noted doubtless by other observers of geological conditions. However, they are brought together here in the hope that the collection may be of assistance to students of structural problems in geology.

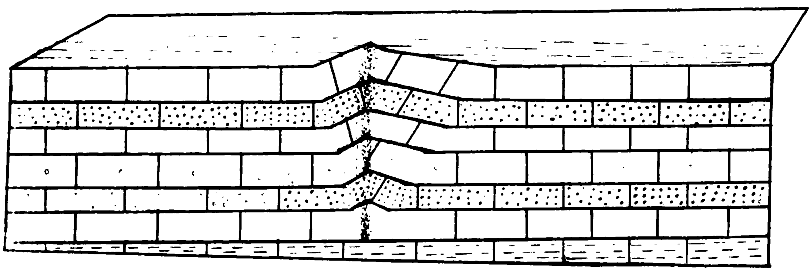

Fig. 1. Cross-section of strata, showing dipping beds with a gulch approximately at right angles to the dip. Right surface of rocks in gulch damp, left surface, dry.

Wet or Damp Surfaces.—In the case of an outcrop extending approximately at right angles to the dip of the beds the exposed surface of the rocks on the lower side of the dipping beds may be bathed in moisture. The presence of the moisture is due to the seepage of water from the porous layers in the rocks. Such seepage can take place only under certain conditions of humidity and would not be noticeable in an arid region. If the outcrop is in a railroad cut or in a stream with precipitous banks the outcrop on the opposite side from the damp surface will be dry because the water is conducted away from its surface, instead of toward it. The conditions are illustrated in the following diagram in which the shaded side of the cut on the down-dip side is kept moist by water flowing along the bedding planes and through porous layers, while the surface of the rocks on the opposite side of the cut is dry because the water is conducted away from the exposure. If

the dip were, say, a southwest dip, then the southward direction of the dip would be revealed by wet surfaces on the north side of outcrops, while the westward dip would be revealed by moisture on the east side of exposures.

Springs.—Such conditions as have been outlined above often result in the formation of springs. Sometimes a chain of springs is formed

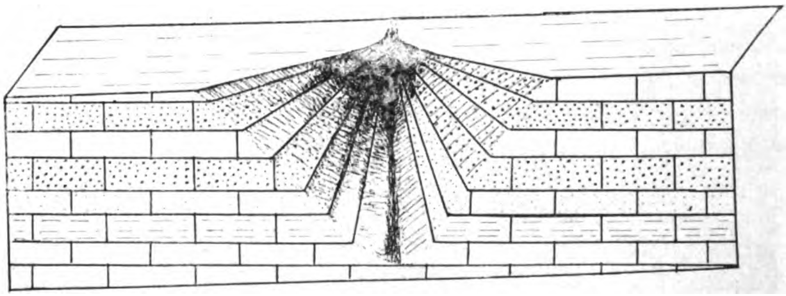

Fig. 2. The case of a stream cutting through strata approximately at right angles to the dipping beds. Springs will be formed at the contact of porous and impervious layers on the left bank of the stream.

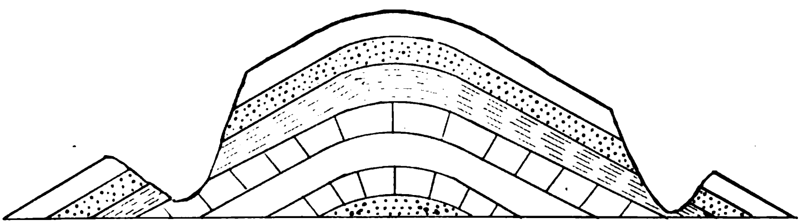

Fig. 3. Showing cross-section of a partly disected anticline. Springs may be formed in the valleys on each side of the axis at the points of contact of pervious and impervious layers.

along an exposure on its down-dip side. The essential conditions for a spring, such as a porous layer overlying an impervious one, must be present. Springs are of especial value as indicia in cases of concealed outcrop. Even if the bed-rock be concealed by mantle rock, springs often break forth at the point of contact of the pervious and impervious beds and by observing the position of these along the valley walls of cross-cutting streams, as in the case of wet surfaces, the direction of dip may be determined.

Springs are also good indicia of reversal of dip. Take for example the occurrence of a porous bed overlying an impervious bed in an anticline. Springs will be formed one each side of the anticline at the point of contact of the porous bed with the impervious one. If the anticline is a symmetrical one a chain of springs may occur at about the same elevation on each side of the fold. If the anticline is unsymmetrical the springs may occur at a higher elevation on one side than on the other.

Springs may also indicate the reversal of dip produced by the downthrow of a block along a normal fault. The springs will occur on the banks of depressions following the general direction of the strike and on the down-dip side of the outcrop.

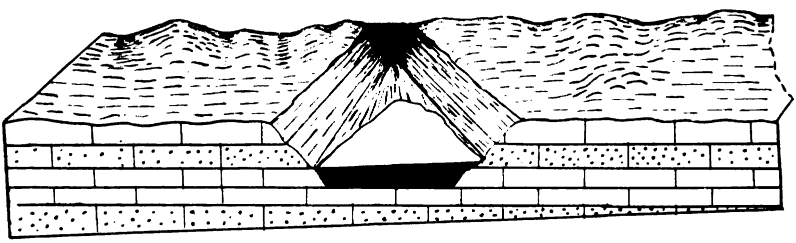

Fig. 4. Shows pool of water formed on surface of dipping bed. Note position of water level with reference to position of bedding planes on each side of pool.

Surface of Pools.—The surface of pools of water in inclined strata furnishes a horizontal plane by means of which even slight degrees of dip may be recognized. The conditions most favorable to such observations are the presence of inclined beds of hard rock or alternate layers of hard and soft rock which have been crossed by a stream in the bed of which pools have been formed. Using the surface of the water in the pool as a level, even slight dips may be detected by the difference in the elevation of the surface of the water upon layers on opposite sides of the pool. If the water stands on the uneroded surface of a hard layer it will have greater depth on the down-dip side of the pool.

Stream Channels.—The channels of dry streams are useful in determining the direction of dip. In the case of a stream trending in a line which is, in general, parallel with the strike and cutting across hard layers or beds composed of alternate hard and soft layers the

stream will be thrown toward the down-dip side. The channel of the stream will have a more gentle slope on the up-dip side and a more abrupt slope toward the down-dip side. The stream, tending to follow the surface of the hard layer in the bottom of the channel, cuts against the bank on the lower side of the inclined bed making that bank more abrupt by under cutting. At the same time the more shallow depositional area of the stream is on the opposite side and its slope is rendered more gentle.

Overhanging Ledges.—Outcrops of rock in inclined strata which contain layers of sufficient induration to project unsupported form on the upper side of the inclined beds overhanging ledges. These ledges occur in layers of hard rock but are more pronounced in outcrops containing alternate layers of hard and soft rock. Slight degrees of dip

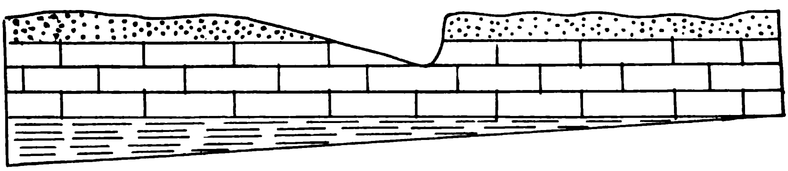

Fig. 5. Notch cut by stream in dipping strata. Note gentle slope on left and abrupt slope on right.

may be noted by observing the plane of shadows under these overhanging rocks. Frequently the direction of dip may be determined by the movement of water on the underside of these ledges.

Caves.—In limestone regions the position of caves serves as an indication of the direction of dip. Wherever a stream cuts through a thick bed of inclined limestone the valley wall opposite the down-dip side of the stream will have a series of caves which mark the positions of tributaries or of former tributaries of the stream. The opposite side of the valley will contain no caves in its wall. If these caves occur on the west side of a valley trending north and south the direction of the dip of the beds is eastward.

In the case of a stream heading in an inclined bed of limestone it frequently happens that more than one cave is formed. Frequently one at each terminal of the small tributaries. If these tributaries be close together and approximately parallel one will necessarily be farther

down on the inclined slope of the beds than the other. Now since these tributaries are supplied with water draining down the surface of the impervious layer beneath the limestone the tributary farthest down on the slope will receive the greater amount of water. Thus it often happens that there is a lower cave from which a stream of water is issuing and an upper cave that contains little or no running water. In regions of such occurrences the cave on the lower part of the slope is referred to as the "wet cave" and the upper one as the "dry cave." The direction of dip is readily determined by the relative positions of these caves.

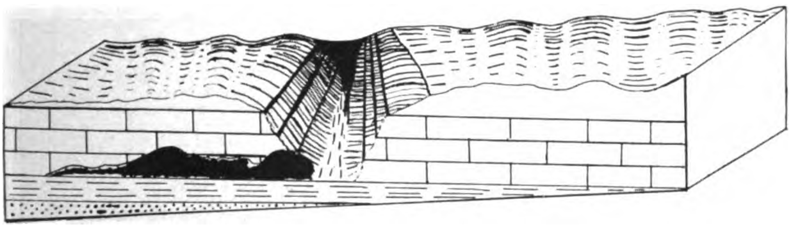

Fig. 6. Shows valley trending at right angles to the dip of inclined strata. Cave and overhanging ledges on left.

Sink Holes.—On moderately to steeply inclined limestone surfaces the shape of the sink holes may be an indication of the direction of dip. As a rule the longer axis of the sink hole will lie parallel to the direction of dip. Erosion produced by water flowing into the sink will be greater on the side opposite the direction of dip. The slope on this side of the sink becomes longer and more gentle. Very frequently there will be one or more short surface streams entering the sink from the side of this gentler slope.

Length of Tributaries.—In the case of a stream cutting in a direction approximately at right angles to the direction of dip the tributaries which follow down the dip will be longer than those which flow up the dip. This would not be true in a rock of uniform hardness devoid of stratification. Such indications are more noticeable in beds containing hard and soft layers of rock.

Indurated Surfaces.—The surfaces of some porous beds of rock which are exposed on the sides of cuts opposite the direction of dip become indurated by the more or less constant evaporation of water

containing minerals in solution. These minerals left behind fill the pores of the rock and unite the individual grains of the rock, thus hardening the surface. The rocks on the opposite side of the cut may lack this degree of induration because, since the dip is away from the outcrop, the greater part of the water is drained away from the surface and the amount evaporated at this point is small.

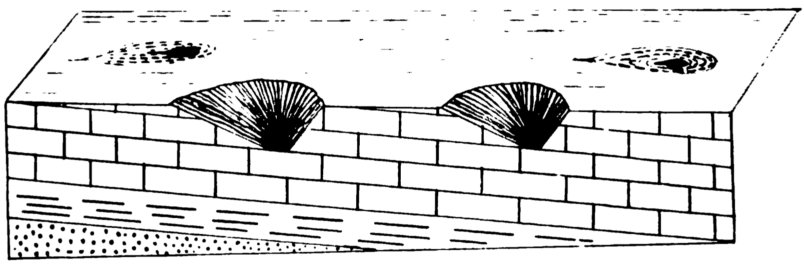

Fig. 7. Cross-section and horizontal section of strata containing sink holes. Note longer axis of holes parallel to the direction of dip.

Deposition of Sediment.—On the surfaces of layers of hard rock which are inclined either in quarries or stream beds the deposition of sediment may indicate the direction of dip. The thicker accumulation of sediment will occur in the direction of the dip. In the case of quarry floors which are formed on the stratification planes the distribution of rock dust and other forms of debris by running water will reveal the direction of the dip.

Distribution of Vegetation.—In inclined beds which outcrop, vegetation is sometimes more abundant on the side of the outcrop opposite the direction of dip. This greater abundance when it does occur is due to the increased amount of moisture and its almost constant supply to the surface of the outcrop through the porous layers which are draining down the dip.

BRIEF NOTES ON FIELD METHODS USED IN GEOLOGICAL WORK OF MID-CONTINENT OIL FIELDS.

LOUIS ROARK—Indiana University.

In writing this article the writer is not attempting to make an elaborate discussion of the various methods nor is he attempting to suggest new methods of doing field work, but instead is endeavoring to bring together in a compact form, various methods commonly used, for the benefit of the young geologist who has not had an opportunity to learn them by actual experience.

No doubt many will take issue with me in regard to the value of some of these methods. However the writer has found them quite satisfactory under certain conditions and within certain limitations.

The geological work as conducted by the different oil companies of the mid-continent field is based upon one fundamental principle, namely, the location of structure favorable to the production of oil. The favorable structure as all know is the anticline. Therefore the geologist is continually searching for the anticline.

The geologist meets with many and varied difficulties in this work. He must follow the outcrops of the various rock strata and obtain elevations at intervals of at least one quarter mile and oftener if necessary. He must also measure the vertical interval between the different strata whenever the two horizons outcrop close together, thus presenting an opportunity to make such measurement. This vertical interval should be measured frequently in order to catch any variation in the interval. These elevations and intervals are used as a basis for drawing the structural contours, thus enabling the geologist to select the most favorable locations for drilling.

The following methods are used to obtain the elevation of outcrops.

1. Plane Table and Stadia Traverse, Using Telescopic Alidade.
2. Setting Bench Marks with Plane Table and Stadia. Geologist Using Aneroid Barometer.
3. Using Aneroid Barometer with Stationary Barograph.

4. Setting Bench Marks with Aneroid Barometer.

5. Reconnaissance (Scouting) Using Aneroid Barometer and Hand Level.

Method No 1.

For close detail work the plane table and stadia traverse is by far the most accurate method and no doubt favored by all geologists.

With this method the party consists of a geologist in charge and an instrument man. The geologist carries the stadia and follows the outcrop, giving stadia readings for location and elevation as frequently as he deems necessary. Between stations the instrument man sketches the drainage, roads and any and other features necessary to make a complete geological map.

At intervals of an hour or an hour and a half the geologist should return to the plane table and sketch the various outcrops on the map and record the vertical interval between the different strata he has mapped.

At night the day's work is inked in and that portion of the map is complete with exception of the structural contours.

This method is favored for open country and areas free from timber growth, and is fairly rapid.

The small telescopic alidade used by the United States Geological Survey is commonly used. The size of plane table depends upon horizontal scale used, varying from 15 inches to 24 inches square.

Method No. 2.

The second method used is not as accurate as first but is much more rapid for use in timber-covered areas.

With this method an instrument man with plane table, stadia and a rodman are sent into the particular area to be mapped. They run a stadia traverse along the roads, establishing bench marks at the corners and other conspicuous places, at least every one-half mile. If the roads are few the bench marks should be established at the end of spurs that extend toward the main stream between tributary valleys. A key system being used to mark the bench marks, the rodman paints the bench marks according to the key used. The elevation and number or key is recorded on the map for use of the geologist.

The geologist now takes the level sheet from the instrument man and by use of the aneroid barometer carries the elevation along the outcrop of rock strata. For the results obtained with the barometer to be of any value care should be taken that the barometer is checked frequently.

The method ordinarily used is to set the aneroid barometer at same elevation as bench mark from which start is made also noting time barometer was set, which is essential. Whenever an elevation reading is made on the outcrop the time of reading should be noted. The barometer must be checked at a known elevation every forty or forty-five minutes and should not be more than an hour between checks for accurate results. The barometer must not be changed after being set at first station in the morning.

At night, plot a curve showing amount of variation of barometer from normal during day. By means of the curve correct all readings for elevations made during the day by adding or subtracting the difference from normal, to the reading to be corrected.

Example: Suppose correction curve shows aneroid barometer was reading 22 feet high at 10:15 and elevation reading on outcrop was 953 feet at same time. To get correct elevation of that point subtract 22 feet from 953 feet which gives 931 feet, the correct elevation. If aneroid barometer was reading low at 10:15 the 22 feet should be added to give correct elevation which would be 975 feet, etc.

While geologist is walking the outcrop, he should sketch the drainage, roads, trend of outcrop of rock strata and other features necessary to make a complete geological map.

After making correction of barometer readings the day's work should be inked as finished, so that the work will not be lost by erasure during work the next day. The inking should be up to date at all times.

The aneroid barometer most commonly used is 2½ inches in diameter graduated to record elevation of 3,000 feet with 10 feet divisions. Frequently larger instruments are used, some as much as 6 inches in diameter. The larger aneroids are the more accurate.

METHOD NO. 3.

The third method is not as accurate as either of the first two, but much more rapid, and can be carried on with less expense, as the plane table and operator are eliminated. With care accurate results can be accomplished with this method.

If a geologist is sent into a field to do a rapid piece of work and time available for doing the work or character of the work would not pay to employ the use of plane table and stadia this method is the most satisfactory one to use. The reader must keep in mind that the element of time is important to the oil geologist. He must finish his work and get report to the chief geologist to pass upon, before another company has an opportunity to obtain lease on valuable acreage that he is likely to report favorable.

In this method a barograph can be used to an advantage in connection with the ordinary aneroid barometer. Set the barograph at some place near center of area to be worked and proceed with aneroid barometer as in Method No. 2, noting time all readings are made. At night, instead of plotting curve as before, use curve of barograph and proceed in same way to make correction for elevations.

If a barograph is not available use two aneroid barometers, one to be stationary and the other carried by geologist. In case two aneroids are used the one stationary should be read every 15 or 20 minutes throughout the day and a curve plotted from these readings. Proceed as before in making corrections for elevations.

METHOD NO. 4.

The fourth method can be used in case it is desirable to detail a small area and neither a plane table, barograph or extra aneroid barometer is available and time is short for completing the work.

The geologist uses his aneroid to establish his own bench marks. An elevation at a certain point may be assumed. Set aneroid at this assumed elevation, noting the time. Drive in a circle making readings at points where bench marks are desired, noting time of readings. Return to starting point within 45 minutes or an hour from time of start. Repeat circuit, checking previous readings. Now these points can be used as bench marks, making circuits from these points establishing

bench marks farther out, checking and rechecking the points to be used as bench marks. Continue this until bench marks have been established over area to be detailed. Plot curve and make corrections for elevations of points to be used for bench marks. After the bench marks have been established the method of procedure is same as in Method No. 2 in all respects.

This method is very good and quite accurate for obtaining quick results.

Method No. 5.

The fifth method is simply reconnaissance work, or scouting, as it is frequently called.

With this method the geologist drives over the country observing the dip of the rock strata by use of the hand level, aneroid barometer or eye.

Wherever an exposure of rock is observed the hand level is used to determine the approximate amount of dip in any distance. The direction of dip may be obtained by use of the compass. The geologist must always know the height of his eye from the ground.

Example: Suppose strata is dipping west and in a distance of one-quarter mile the geologist finds the dip to be five times the height of his eye which is 5 feet 6 inches, therefore the rock would be dipping 27 feet 6 inches in one quarter mile, etc.

The aneroid barometer may be used in scouting to determine approximate amount of dip for short distances. Read elevation of outcrop, then follow strata for distance exposed, with occasional readings, noting amount of variation from first reading. This gives the amount of dip.

Example: If aneroid reads 700 feet at a given point and outcrop is followed east one-quarter mile and then reads 670 feet, showing strata dips east 30 feet in one quarter mile. Supposing second reading was 732 feet then strata dips west 32 feet in one quarter mile, etc.

An experienced geologist should be assigned to scouting work. The greatest value of this method is that it permits a large territory to be covered rapidly and a great part eliminated. An experienced man will be able to find most of the structure. Later, if deemed advisable, the various structures reported by the scout can be worked in detail by either of the first two methods.

AN IMPROVED FORM OF MERCURY VAPOR AIR PUMP.

CHAS. T. KNIPP—University of Illinois.

(Abstract.)

The mercury vapor pump described in this paper retains the same simple valve arrangement described recently by the writer,* but on the other hand replaces the umbrella that deflected the mercury vapor downward through an annular throat by the commonly used aspirator nozzle through which the vapor issues vertically upwards. This necessitates an interchange of connections leading to the supporting pump and the vessel to be exhausted.

This pump, single stage, will operate on any oil supporting pump of the grade of the Nelson pump. In addition to its speed, its simplicity of design and ease of construction are important points, and when constructed of pyrex glass is durable.

The paper also gives the data obtained when several of these pumps are placed in tandem. Again, a three-stage pump retaining the same general principle is described, designed to operate on a poorly working water aspirator as a supporting pump. The mercury vapor for each stage is supplied from the same boiler, yet at different pressures, the highest pressure to the first stage exhausting into the aspirator. Sample pumps and sketches were exhibited.

* Phys. Rev., N. S. IX, No. 3, March, 1917.

A Possible Standard of Sound.

Chas. T. Knipp—University of Illinois.

(Abstract.)

The paper as presented described a source of sound recently brought to the writer's attention, while blowing a mercury vapor trap of pyrex glass, that bids fair to furnish a standard of sound of any desired pitch with no other apparatus than the trap and a bunsen burner. In its simplest form the apparatus is an ordinary trap as shown in Fig. 1, having the usual ring seal at M.

To operate, close A with a sliding piston of cork, let C remain open, and apply a bunsen burner (adjusted to give a fairly hot flame) at B. The tube AB should be held in the flame at an angle so that the central portion M is not unduly heated. When B begins to glow, a pure tone that is readily audible over a large room is emitted at C. The pitch of the sound is dependent upon the length of the vibrating column AB and also upon the length of the side tube MC. Attaching a horn at C intensifies the sound many fold. The only opening is at C, yet a candle placed at this point is instantly blown out. On closer examination it was noticed that a current of air *enters* the tube C around its edge, and another at the same time *escapes from it* along its axis.

There are other conditions that affect the pitch. Those noted thus far are: That heating the region about M destroys the sound; but on the other hand if the flame is removed from B, then C stopped and A opened, the tube will again operate on *heating M to redness;* that the pitch is raised by the addition of extra side tubes fused to the vibrating column at M, and is instantly lowered when these extra branches are in turn stopped.

Tubes having different dimensions were constructed. These can be adjusted over wide ranges—each an octave or more—and all give, apparently, clear tones particularly free from overtones. By supplying heat to the end B at a constant rate (as by an electric furnace) the pitch may be kept constant for an indefinite length of time. The apparatus should therefore furnish a standard source of sound.

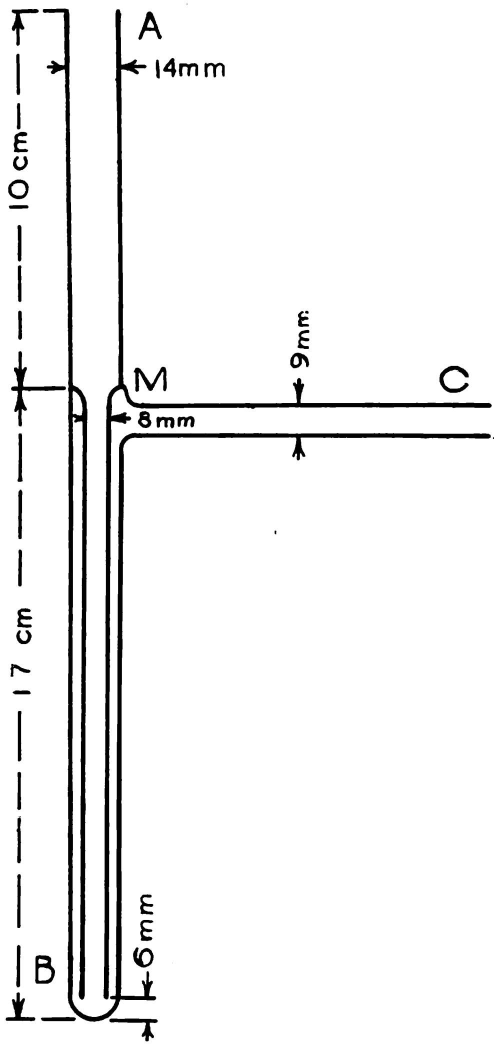

FIG. 1. A possible standard of sound.

Energy Losses in Commercial Hammers.

Edwin Morrison and Robert L. Petry—Earlham College.

It is a well-known principle of mechanics that, in case a moving object impinges against another object, that the total momentum before impact is equal to the total momentum after impact. In other words, "That momentum is conserved in all impacts, be it between elastic or inelastic objects." This law does not permit us to infer, however, that there are no energy losses in impacts. In fact the kinetic energy is always less after impacts than before impacts of two impinging objects. By testing this out by ordinary laboratory methods we find these energy losses to vary from as high as eighty per cent in case of inelastic impacts to as low as two per cent in elastic impacts.

In teaching this subject I have for a number of years attempted to illustrate and fasten these principles in the mind of the student by such questions as the following: Suppose a carpenter is employing a number of men in a mechanical process, such as the driving of nails with a hammer, would it be of importance for him to look into the grade of hammers used? Or again: Suppose a railroad company is retracking its line and it is necessary to drive thousands of spikes, does it matter whether the sledge hammers used are made of cast iron or a high grade of steel?

It so happened that my present class inquired as to whether it would be possible to try these conditions out in an experimental way. After a moment's reflection I informed them that it would be a very simple matter to make tests by substituting a hammer for one of the steel spheres in our impact machine. This has been done in the case of four hammers with considerable care.

The apparatus used was similar to that employed in Experiment 6, page 62, in Millikan's Mechanics, Molecular Physics, and Heat. One of the steel spheres was removed and the hammer to be tested was substituted in its place as shown in Fig. 1. In order to support the different hammers as nearly as possible under the same conditions, a frame was suspended by four adjustable cords, to which the hammers could be

rigidly bolted. The experiment consists in displacing the hammer to a certain angular position to one side the normal position and allowing it to drop and impinge upon the steel sphere, noting the maximum angular displacement of both the steel sphere m_1 and the hammer after impact.

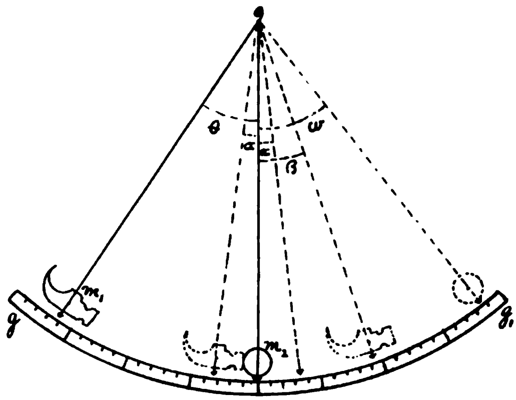

Fig. 1.

The following equations are applicable:

$$\text{The Coefficient of Restitution} = \xi = \frac{\sqrt{(1 - \cos\omega)} - \sqrt{(\cos\alpha - \cos\beta)}}{\sqrt{(\cos\alpha - \cos\theta)}}, \quad (1).$$

The percentage loss of K.E. $= l = (1 - \xi^2)\dfrac{m_2}{m_1 - m_2}$, (2) The values of α, β, θ, and ω are measured directly upon the graduated scale gg_1.

TABLE I.

	Mass of Sphere. m_2	Mass of Hammer.	Mass of Suspending Frame.	Total Mass. m_1.	α In Deg.	β In Deg.	θ In Deg.	ω In Deg.	ξ From Equation 1.	l From Equation 2.	Average l.
No. 1	232.9	659.0	123.3	782.3	2.97	6.08	10.0	14.4	.9539	2.063	......
No. 1	232.9	659.0	123.3	782.3	2.97	6.63	11.0	15.9	.9405	2.645	2.354
No. 2	232.9	518.8	123.3	634.1	3.27	5.82	10.5	13.8	.8981	5.193	......
No. 2	232.9	518.8	123.3	634.1	3.27	6.29	11.5	15.2	.8945	5.364	5.297
No. 3	232.9	332.6	123.3	455.9	3.00	4.70	9.9	11.8	.8618	8.693	......
No. 3	232.9	332.6	123.3	455.9	3.00	5.71	13.0	15.5	.8406	9.921	9.307
No. 4	232.9	245.6	123.3	368.9	3.02	5.95	15.0	15.2	.6829	20.65	......
No. 4	232.9	245.6	123.3	368.9	3.02	4.91	12.0	15.3	.7265	18.27	19.46

Hammer No. 1 was a high-grade machinist hammer.

Hammer No. 2 was a claw hammer purchased as a high-grade tool.

Hammer No. 3 was a lower-grade machinist hammer.

Hammer No. 4 was a cast-iron hammer purchased at a five and ten cent store.

The steel sphere used in the above experiment, when tested with a similar sphere, gave an average of approximately two per cent energy loss.

Conclusion: The experiment justifies the conclusion that high-grade steel hammers conserve to a much larger degree the kinetic energy of a blow than low-grade cast-iron hammers.

THE EFFECT OF ARTIFICIAL SELECTION ON BRISTLE NUMBER IN DROSOPHILA AMPELOPHILA.

FERNANDUS PAYNE—Indiana University.

The following brief abstract gives a summary of the results obtained in an experiment designed to test the effect of artificial selection on bristle number in Drosophila ampelophila, and to find out in what way selection is active.

The normal number of bristles on the scutellum is four. In a mass culture which had been bred in the laboratory about three months, a female was found with one extra bristle, or five in all. This female was mated to a male from the same mass culture. Of the F offspring, two females had five bristles. These two females were mated to their normal brothers, and gave in F^2, 935 normal flies, thirty-nine with five bristles, and four with six bristles. The flies with extra bristles were again mated and this method of selecting the high-grade parent has been continued throughout the experiment. The per cent of extra bristled flies and the mean bristle number have been gradually increased until in the last generations of selection no normal flies were found and the mean reached 9.089 in the twenty-eighth generation. From the twenty-eighth to the thirty-eighth generations, the mean remained practically the same. A back selection line started from the eleventh generation was without effect.

Selection then has produced decided results. The larger question is, how have the results been produced? Have they been produced by selecting somatic variations, by selecting the variations of the gene which stands for bristle number, or have they been produced by piling up or getting rid of modifying factors? The first possibility can be dismissed without much consideration, as any character which is inherited must be germinal. Of the other two possibilities, my evidence is in favor of the latter. It shows quite conclusively, I think, that there is a factor in the X-chromosome and also one in the third chromosome which modifies bristle number. There may be more than two such factors. One was no doubt present at the beginning of the experiment. The others probably occurred as mutations during the course of selection.

The Unionidæ of Lake Maxinkuckee.

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and
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During the physical and biological survey of Lake Maxinkuckee carried on by the writers at intervals from 1899 to 1913, under the auspices of the United States Bureau of Fisheries, considerable attention was devoted to the freshwater mussels or clams (Unionidæ) inhabiting that lake. This was justified by the rapid and astonishing development of the pearl button industry in America, which is dependent upon the shells of the mussels for its raw material. The recent development of methods whereby several species of Unionidæ are now successfully propagated artificially adds special interest to the study of these mollusks.

Lakes and Ponds as the Home of Mussels.

Generally speaking, lakes and ponds are not so well suited to the growth and development of mussels as rivers are; the species of lake- or pond-mussels are comparatively few, and the individuals usually somewhat dwarfed. Of about 84 species of mussels reported for the State of Indiana, only about 24 are found in lakes, and not all of these in any one lake, several of them but rarely in any. Of the 24 species occasionally found in Indiana lakes, but 5 are reported only in lakes, and only 3 or 4 of the species common to both lakes and rivers seem to prefer lakes.

In rivers, the essential feature favorable to the development of mussels is the current; and in rivers the mussel beds reach their best development on riffles, where the current is strongest. The importance of the current to the well-being of the mussels is indicated by the position these mollusks naturally assume in the beds, the inhalent and exhalent apertures of the creatures being upstream against the current. The importance of the current is not merely as a bringer of food; examina-

tions show that the mussels of the plankton-rich lakes and ponds usually contain more food material than those of the rivers. The current gives the river-mussels the advantage of a constant change of water, which means a more abundant supply of oxygen, and doubtless a more varied supply of mineral matter, from the various sorts of soil through which the river flows. The current is also probably of considerable importance in assisting in the fertilization of mussels, one of its results being the conveyance of sperm from mussels in upper portions of the bed to other mussels below. In places where there is no current, fertilization must be more largely a matter of chance.

Although the majority of species of mussels prefer a river where there is a good current, some are more fitted to the quieter parts of streams, or to ponds. These are chiefly thin-shelled species with weakly developed or undeveloped hinge-teeth, best represented by the genus *Anodonta*. In some places Anodontas are known as pond-mussels, to distinguish them from the heavier sorts, or river-mussels.

The distinction between lakes and rivers is not constant in degree; we have all sorts of gradations from the extreme form of lakes—isolated bodies without outlet—through lakes with relatively large, important outlets, to such lakes as are simply expansions of a river-bed, examples of the latter type being Lake Pepin, Minn., of the upper Mississippi, and the former English Lake in Indiana, an expansion of the Kankakee. As a usual thing, the more fluvatile a lake is, or the larger and more river-like its outlet, the more river-like will be its mussel fauna, both in abundance and species. In such lakes the mussels retain a vital continuity with the mussel beds of the river. In the less fluvatile lakes the mussels are more isolated, and there is more inbreeding. The large number (24) of lake-dwelling species recorded for Indiana is due to the fact that some of the lakes of Indiana are more or less fluvatile, and contain several species of river shells.

Origin and Character of the Maxinkuckee Mussels.

Lake Maxinkuckee, having a long, narrow, and relatively unimportant outlet, is a representative of one of the less fluvatile types of lakes, forming a pretty well marked contrast to the various lakes cited above, and bearing a pretty close resemblance to the neighboring lakes, such as Twin Lakes, Pretty Lake, Bass Lake, etc.

The Maxinkuckee mussels are doubtless derived from ancestors brought up the Outlet from the Tippecanoe River by ascending fishes. It is doubtful whether any have been introduced by the numerous plants of fish in the lake, though such a thing is possible. During various times the lake was visited, a few Tippecanoe River mussels were planted in the thoroughfare between the lakes, and a few Yellow River and Kankakee mussels were planted in the main lake.

The Outlet of Lake Maxinkuckee is now a narrow, shallow, winding stream, straightened in places by ditching, and bordered on each side by a flat sedgy plain which indicates the former breadth and importance of the stream. The colonization of the lake with mussels was probably effected chiefly during the period when the Outlet was a broad and relatively important stream. The situation has been carefully considered and seems to show that the mussels of the river and lake are isolated from each other and that there is no longer any vital connection between them. The strongest indication of the independence of the lake and river mussel faunas is the appearance of the Maxinkuckee mussels themselves; these are lake-mussels, easily distinguished for the most part from the river-mussels of the same species, and many of them are distinguishable also from the mussels of the neighboring lakes.

The Tippecanoe River is fairly well supplied with mussels. Although the number of species is considerably fewer, and the size of the individuals is generally smaller than those of the Wabash into which it flows, it compares very favorably with rivers of its size. At Delong, Ind., a short distance above the mouth of the Outlet of Lake Maxinkuckee, specimens were obtained in one bed representing twenty-four species of mussels, or about twice the number of kinds found in Lake Maxinkuckee.

Our knowledge of the extent and importance of migrations of fishes from the Tippecanoe River up to the lake and from the lake down to the river—a question which has a marked bearing upon the relationship of the mussel faunas—is not as complete as it should be, but indications are that they are not important or extensive. Inasmuch as the geographic distribution of a given species of mussel is coextensive with that of the species of fish which serves as its host, this question is

worthy of careful consideration. There are several species of fishes of the Tippecanoe River (*Etheostoma camurum, Hadropterus evides, Hybopsis amblops,* etc.), which were not found either in the Outlet or in the lakes, and other species (*Hadropterus aspro, Ericymba buccata, Diplesion blennoides*) which have pushed half way up the Outlet, but were found no further up.

In this connection, the mussel fauna of the Outlet is worthy of consideration, and on various occasions, but especially on a trip down the Outlet September 30, 1907, particular attention was paid to this feature.

The Outlet is not particularly well suited to the growth and life of mussels. The bottom is either a firm peaty soil or fine shifting sand; moreover, the course has been artificially changed in some places and the stream has naturally shortened its length in others by making cutoffs. In addition to this the mussel fauna of such a narrow shallow stream would be the prey of muskrats, minks, etc., the entire length and width of the beds.

On the trip mentioned above, about a mile below Lost Lake a fine example of *Lampsilis iris* was found. This is the farthest up stream any species of mussel was obtained, and as this species is fairly common in both lakes and abundant in the Tippecanoe River, we have here the nearest approach to a continuous fauna. Some dead shells but no living examples of *Quadrula undulata* were found a little farther down. Farther down stream from a quarter to half a mile, a short distance above the second cross-road south of the lake, was found a small mussel-bed of about forty or fifty mussels, the great majority of which were *Quadrula undulata*. A few living *Lamrsilis iris*, two dead *Symphynota compressa*, one living *Symphynota costata* (gravid) and a few dead shells of *Quadrula coccinea*, complete the list. Below this point no mussels were found until near where the Outlet joins the Tippecanoe. Here, a few rods up the Outlet, a fair bed of *Quadrula coccinea* was found. Of the five species of mussels found in the Outlet, only two, *L. iris* and *Q. coccinea*, are found in the lake, the latter but rarely. The form and general appearance of the *Q. undulata* of the Outlet is quite peculiar and they can be picked out at once from collections from the various rivers of the country. They are unusually elongate, in this respect resembling some of the Tippecanoe mussels but differing from them in

being thinner, and in having the furrows between the plicæ unusually deep and sharp. The costæ on the posterodorsal slope are very marked, and the epidermis is jet black. The umbones are considerably eroded.

Distribution of Mussels in the Lake.

In rivers, where there is a great variety of conditions, such as differences of current, bottom, etc., one finds the different species of mussels inhabiting different localities and different situations. In the lakes, where we have comparatively few species of mussels and not such important differences of environment, the distribution of the various species is much the same. The same conditions, such as rather shallow water and moderately firm bottom, are equally suitable for all. A few important exceptions may be noted, as for example, the less common species of the lakes are often more or less local in distribution. The only well-marked bed of *Quadrula rubiginosa* in the lakes is in the Lost Lake mussel-bed below the Bardsley cottage, and this is the only place where *Lampsilis subrostrata* can be collected in any considerable numbers. *Lampsilis glans* has a marked preference for the shallow water at the edge of the thoroughfare between the lakes; occasional examples can, however, be picked up almost anywhere along the shore, and it appears to be increasing considerably along shore at Long Point. *Anodonta grandis footiana,* which can live in softer bottom than the other mussels, has a considerably wider distribution, and was dredged in deeper water than any of the other mussels.

The mussels are to be found almost anywhere in water from 2 to 5 or 6 feet deep where the bottom is more or less sandy or marly. The beds are composed chiefly of the three principal species of the lake, *Lampsilis luteola, Unio gibbosus* and *Anodonta grandis footiana,* with the less common species sparsely interspersed. Especially good mussel beds occur at Long Point, along shore by Farrar's and McDonald's, along the depot grounds in Aubbenaubee Bay out from the Military Academy, and in the shallow water just beyond the mouth of Norris Inlet. Mussels are fairly well scattered from Long Point more or less continuously all the way southward to beyond Overmyer's hill, and from a little north of the ice-houses all the way around to the Military Academy. They are quite abundant in the neighborhood of Winfield's

in shallow water, and occur scattered along the east side of the lake a little way out from the shore. A good mussel bed is found in Lost Lake along the east shore, extending from a little south of the Bardsley cottage to where the bullrushes and water lilies grow thickly in the soft black muck near the shore.

Movements.—Closely connected with the question of distribution is that of movement. The greater number of mussels of the lake, especially in the deeper water, spend their lives in a state of quiescence. Young mussels appear to be more active than older ones. The mussels retain the power of locomotion during all their lives, but after they have got well settled down, they only occasionally use this power. The mussels in shallow water near the shore move into greater depths at the approach of cold weather in late autumn or early winter and bury themselves more deeply in the sand. This movement is rather irregular and was not observed every year. It was strikingly manifest in the late autumn of 1913, when at one of the piers off Long Point a large number of furrows was observed heading straight into deep water, with a mussel at the outer end of each. The return of the mussels to shore during the spring and summer was not observed. Many of them are probably washed shoreward by the strong waves of the spring and summer storms, and some are carried shoreward by muskrats and dropped there. Occasional mussels were observed moving about in midwinter, even in rather deep water. During the winter of 1900-1901, an example of *Lampsilis luteola*, in rather deep water in the vicinity of Winfield's, was observed to have moved about 18 inches in a few days. Its track could distinctly be seen through the clear ice.

As a result of the quiescence of the lake mussels, the posterior half or third of the shells, which projects up from the lake bottom, is usually covered by a thick marly concretion which appears to be a mixture of minute algæ and lime. This marly concretion grows concentrically, forming rounded nodules, its development increasing with the age and size of the shell. This concretion, though most abundant on shells, is not confined entirely to them, but grows also on rocks that have lain undisturbed on the bottom. When growing on shells, it adheres to them very closely; and upon being pried loose sometimes separates from them much as the matrix separates from a fossil, and leaves the epi-

dermis of the mussel clean. In other cases it adheres more closely and is difficult to scrape off clean. On this marly growth, colonies of *Ophrydium*, much the size, color, and general appearance of grapes with the skin removed, are often found growing, and in the cavities and interstices of the marl, a handsome little water-beetle, *Stenelmis sulcatus* Blatchley, and its peculiar elongate black larvæ, lives in considerable numbers but apparently has nothing to do with the mussels. Various species of hydrachnids, one of them strikingly handsome with its green body sprinkled with bright red dots, also live in the cavity of the marl, and offer some suggestion as to how the parasitic mite *Atax* went a step farther and took up its habitation within the mussel itself.

Food and Feeding.—An examination of the stomach and intestinal contents of the various species of mussels of the lake showed no noticeable difference between the food of the different species. Enough of the bottom mud is generally present to give the food mass the color of the bottom on which the mussels are found. Thus the stomach-contents of the mussels found in the black bottom of Lost Lake were usually blackish, while that of those found in the lighter bottom at Long Point were grayish. Intermixed, however, with the whole mass was always enough algæ to give it a somewhat greenish tinge, this green being usually intermixed more or less in the form of flakes. A striking contrast between the stomach contents of mussels inhabiting lakes and those found in rivers is the much greater preponderance of organic matter in the food of the lake mussels. The stomach contents of river-mussels is generally chiefly mud, with a few diatoms, desmids, *Scenedsmus* and *Pediastrum* intermixed, as said above. Those of the lake mussels are almost always full enough of algæ to be more or less flecked with green and sometimes the whole mass is decidedly greenish. On being placed in a vial of preserving fluid (3 per cent formalin was generally used) and shaken, the material from the river mussels always retains the uniform appearance of mud; that from the lake mussels separates, the mud settling to the bottom and the organic material settling as a light flocculent mass above the more solid portion. This top layer is composed of the various plankton elements of the lake, and was found to vary considerably in different lakes. In the Lake Maxinkuckee mussels it was found to consist chiefly of such species as *Mi-*

crocystis æruginosa, Botryoccus braunii, Cœlosphærium kuetzingianum, various diatoms, such as species of *Navicula, Rhoicosphenia, Gomphenema, Cyclotella,* and *Cocconema,* various forms of desmids, especially *Cosmarium* and *Staurastrum,* various forms of *Scenedesmus,* considerable *Peridinium tabulatum,* and short filaments of *Lyngbya. Pediastrum,* both *boryanum* and *duplex,* are here, as almost everywhere, rather common objects encountered in the intestines of mussels. Casts of the rotifer *Anuræa cochlearis,* and one of the small entomostracan, *Chydorus,* were occasionally encountered. In one of the Lost Lake mussels, *Dinobryon,* an exceedingly frequent element of the mussel-food in Lake Amèlia, Minn., but rare here, was found.

No opportunities were had to study the stomach contents during the winter, the mussel work having not been taken up to any extent during the earlier part of the survey. Mussels obtained quite late in autumn contained much the same material as in summer. The open and apparently active inhalent and exhalent apertures noted throughout the winter in some individuals would indicate that the mussels—at least some of them—do not hibernate, but carry on life processes more or less actively the year round. The presence of pretty well-marked growth rings would indicate, however, annual rest periods. As diatoms appear to be much more abundant in the water during the winter, it is probable that they enter more plentifully into the mussel's bill-of-fare during the late autumn, winter, and early spring, than during the summer. In considering the mussels as feeders on plankton elements, it is worth while to investigate whether these are not of benefit to the lake as reducers of the excessive amounts of such undesirable elements as *Lyngbya, Anabæna* and *Microcystis,* and whether a considerable increase in the mussel population by means of artificial propagation would not clear up the lake to a considerable extent.

The following studies of stomach contents and table of mussel food are by no means exhaustive, but represent hurried examinations and a record of the more easily recognized forms out of a mass of doubtful material. They are intended to be simply suggestive.

Closely connected with the question of food and nutrition is that of the size of the mussels. A marked feature of the mussels of Lake Maxinkuckee, as well as of the neighboring lakes, is the dwarfing of many of the species, and this is rather difficult to explain when one

considers the large amount of organic material they ingest. The mussels of a few northern lakes examined were thick-shelled and large. So this dwarfing may not be necessarily associated with lake conditions, that is, absence of current. A possible explanation is that of close inbreeding, there being no admixture of new blood with other distant colonies, such as is possible where the lake is in close connection with a large river and its mussel beds.

Breeding Habits, Reproduction, etc.—The reference to inbreeding above leads to a consideration of breeding and breeding habits. At first glance it would appear that lakes, having no, or only feeble, currents, would make fertilization of the ova of the female mussels largely a question of chance. It is not possible, with the data at hand, to make precise comparisons between number of gravid females of the mussels of lakes and rivers during the proper seasons, but the general impression gained from having examined the various mussels of numerous lakes and rivers through the different seasons is that there are fewer of the mussels of the lake that succeed in having their ova fertilized. Gravid mussels are indeed not rare in the lake at proper seasons, but they seem to be much fewer than one might expect. On October 17, 1907, for example, of 252 *Lampsilis luteola* examined, 41 were of the characteristic female form but only 25 were gravid. Likewise, of 18 Anodontas examined on the same date, only 2 were gravid. This is a considerably lower percentage than one would expect in rivers at this date. There are other indications that the functions of reproduction are much less prominent in the lake than in rivers. In the height of the spawning season certain species of mussels, especially *Lampsilis ventricosa* and *L. multiradiata*, exhibit, in the neighboring rivers, a very striking appearance, due to the excessive development and high coloration of portions of the mantle near the inhalent aperture. Though both these species are found in the lake, none was observed in this condition. In some rivers in densely crowding beds, moreover, one frequently encounters precocious individuals; small shells, usually apparently only 2 or 3 years old but gravid with the characteristic female contour markedly developed. This is possibly related to opportunities of fertilization of ova, and is most frequently observed in *L. ventricosa* and *L. luteola*. No such precociously developed mussels were found in the lakes.

A large and well developed female *Lampsilis ventricosa* was trans-

planted from Yellow River into Lake Maxinkuckee. On being examined two years later in the autumn, when this species is usually gravid, it was found to be sterile.

The natural infection of fishes of the lake with the glochidia of the mussels does not appear to be common. The gills of an immense number of fishes were examined for parasites, but no glochidia were noted. Some young bluegills and redeyes, exposed to the glochidia of *L. luteola* in the autumn of 1912, took very readily.

The young mussels were either few, or very difficult to find. Diligent search was made for them, especially in the sandy bottom near Long Point, the sand being scooped up and seived through fine-meshed seives. Numerous and varied forms of life were thus obtained, such as *Sphærium*, *Pisidium*, caddis cases, etc., and rather small but by no means minute examples of *L. luteola* found. These young shells were remarkably brightly rayed. Half-grown *Q. rubiginosa* were fairly common in the beds of Lost Lake.

Proportion of Various Species in the Lake.—Of a collection of 340 living mussels collected October 17, 1907, at Long Point, 252 were *Lampsilis luteola*, 41 *L. ventricosa*, 21 *Unio gibbosus*, 18 *Anodonta grandis footiana*, 5 *Strophitus edentulus*, and 3 *Lampsilis subrostrata*. In deep water *U. gibbosus* and *Anodonta* would have given a higher percentage, and in the Lost Lake beds *Quadrula rubiginosa* would be present in considerable relative abundance.

Parasites, Enemies, and Diseases.—As a general rule the mussels of lakes, ponds and bayous are more heavily infested with parasites than those of the swiftly flowing rivers, the probable reason being that in still waters the parasites can migrate more easily from one mussel to another than where there is a swift current. The mussels of the lake are not nearly so badly parasitized as those of the sloughs of the Mississippi, the dead waters in the Maumee above the dams, or those of the Twin Lakes a few miles to the north. The parasites will be taken up more fully in consideration of the various species of mussels. Several species of *Atax*, and *Cotylaspis insignis* are the most common parasites. Unlike the mussels of most of our rivers, the mussels of the lakes are comparatively exempt from destruction by man. A few are killed and used for bait, and now and then a mild case of pearl fever appears at the lake, but it is soon cured by the examination of a bushel

or two of mussels. On September 22, 1907, a man was seen at the south end of the lake with about a peck of shells which he had opened in a vain search for pearls; on October 8 of the same year, a pile of about a half bushel of shells, which had evidently been opened by pearlers, was found in Overmyer's woods. Another pearler was seen in 1907 who had collected a few slugs of almost no value. One of the citizens of Culver, in 1906, submitted a small vial of lake baroques for valuation, but they had no worth whatever. The greatest enemy of the lake mussels is the muskrat, and its depredations are for the most part confined to the mussels near shore. The muskrat does not usually begin its mussel diet until rather late in autumn, when much of the succulent vegetation upon which it feeds has been cut down by the frost. Some autumns, however, they begin much earlier than others; a scarcity of vegetation or an abundance of old muskrats may have much to do with this. The rodent usually chooses for its feeding grounds some object projecting out above the water, such as a pier or the top of a fallen tree. Near or under such objects one occasionally finds large piles of shells. The muskrat apparently has no especial preference for one species of mussel above another, but naturally subsists most freely on the most abundant species. These shell piles are excellent places to search for the rarer shells of the lake.

On September 24, 1907, about a bushel of shells, recently cleaned out by muskrats, was found at Long Point where a pier had been removed not long before. The shells were all of rather small size and were in about 18 inches of water. About half were taken and examined. Of these shells, 358 were *Lampsilis luteola,* 167 *Unio gibbosus,* 6 *Lampsilis iris* and 1 *Lampsilis multiradiata.* In the autumn of 1913 freshly opened shells of *Lampsilis glans* were common along shore at Long Point. The first shells killed are rather small and are probably killed by young muskrats.

In the winter after the lake is frozen, great cracks in the ice extend out from shore in various directions, and this enables the muskrat to extend his depredations some distance from shore in definite limited directions. During the winter of 1904 a muskrat was observed feeding on mussels along the broad ice-crack that extended from the end of Long Point northeastward across the lake. The muskrat was about fifty feet from the shore. It repeatedly dived from the edge of the ice-

crack, and reappeared with a mussel in its mouth. Upon reaching the surface with its catch, it sat down on its haunches on the edge of the crack, and, holding the mussel in its front feet, pried the valves apart with its teeth and scooped or licked out the contents of the shell. Some of the larger mussels were too strong for it to open, and a part of these were left lying on the ice. The bottom of the lake near Long Point, and also over by Norris's, is well paved by shells that have been killed by muskrats. Muskrats do not seem to relish the gills of gravid mussels; these parts are occasionally found untouched where the animal had been feeding.

Species of Mussels Occurring in Lake Maxinkuckee.

1. *Quadrula coccinea* (Conrad).

Rare at the lake; this is a river rather than a lake shell and would be expected in abundance only in fluviatile lakes, or lakes with broad short outlets and vital connection with river faunas. The few living mussels of this species found in the lake would probably represent a vanishing remnant of a fauna introduced when the lake had a broader outlet than at present and communication with the river below more active. A few dead shells were found along the north shore at various times. On October 25, 1907, a shell 1.75 inch long was found near the railroad bridge at Culver, and in 1909 another small shell was found along shore at Aubeenaubee Bay. Some fine large examples, brought up from the Tippecanoe were planted in the thoroughfare below the railroad bridge, but they have probably been covered and suffocated by sand.

2. *Quadrula rubiginosa* (Lea).

More common in Lake Maxinkuckee than *Q. coccinea*, but nevertheless rather rare, only a few dwarfed shells having been found. In Lost Lake below the Bardsley cottage it was a fairly common species. None of the shells found was of large size, but all were well-formed and handsome. The older shells are almost jet black and peculiarly elongate, with the umbones markedly anterior in position. They look considerably unlike those of either the Tippecanoe or Yellow River, but a form much like the Lost Lake shells was found in the lower course of the Kankakee. No gravid examples were found in the lake. Half grown examples are rather common in Lost Lake, but as they are usually buried consider-

ably deeper in the sand than the older shells, they are harder to find. These half-grown shells are of a peculiarly beautiful golden yellow color with a satiny epidermis, and are of the same shape as those found in the neighboring rivers, that is, the normal or usual shape of the species. The peculiar elongate form of the adult is therefore evidently the product of local influences. The young shells are very iridescent and translucent, much more so than those found in rivers.

Q. rubiginosa is at its best a very fair button shell, but the lake shells are too small to work up well. This species appears to be rather rare in lakes. The only lake examples of this species with which the Lost Lake shells were compared were some obtained in Lake Erie. The Lake Erie shells are much more dwarfed, but very solid.

Food.

The following is the result of an examination of the material found in the intestines of *Q. rubiginosa* from Lost Lake.

Sample 1. August 2, 1908. Mass fine flocculent rather brownish green material, cohering somewhat in cylinders; looks as if chiefly organic; not gritty to touch. Organisms present: *Scenedesmus, Fragilaria, Tetraedron, Navicula, Peridinium tabulatum, Anuræa,* and *Botryococcus braunii.*

Sample 2. August 20, 1908. A large amount of material. Appearance in vial: bottom black, top a fine flocculent sediment. In the top material are *Tetraedron, Scenedesmus, Microcystis æriginosa* and many disassociated minute cells. Black bottom composed of *Anuræa, Lyngbya æstuarii,* a long filament; *Scenedesmus,* many *Peridinium tabulatum, Tetraedron, Epithemia turgida, Merismopœdia,* cast of *Cyclops, Melosira crenulata, Glœocapsa, Staurastrum, Pediastrum boryanum, Gomphonema, Chætophora, Cosmarium,* sponge spicule, *Gomphosphæria aponina,* and *Botryococcus braunii.*

Sample 3. August 20, 1908. A small amount of flocculent brownish material. *Microcystis æruginosa, Peridinium tabulatum* many, and a good many empty cuirasses, *Chydorus, Eudorina,* a few; *Scenedesmus,* common; Diatoms, *Pediastrum duplex.*

Sample 4. August 20, 1908. Fine blue-green flocculent material. *Lyngbya æstuarii,* several filaments; *Microcystis æruginosa,* common;

Cœlosphærium kuetzingianum, Peridinium tabulatum, very abundant; *Chydorus, Anuræa, Botryococcus braunii, Cœlastrum, Staurastrum* 1, small. Naviculas, several.

Sample 5. August 20, 1908. Fine bluish-green material. *Peridinium tabulatum,* abundant; *Cocconema cymbiforme, Navicula,* a few; *Anuræa cochlearis, Microcystis æruginosa, Chydorus,* 1 entire, and other fragments; *Pediastrum duplex, Cœlosphærium kuetzingianum; Cosmarium, Coscinodiscus, Scenedesmus,* very common; *Merismopœdia glauca.*

Sample 6. August 20, 1908. A small amount of flocculent grayish material. *Peridinium tabulatum,* abundant, agglutinated in masses; *Microcystis æruginosa,* very common; *Navicula, Staurastrum, Cosmarium,* several; *Chydorus,* fragment; *Scenedesmus,* small forms, common; *Pediastrum boryanum, Cocconema cymbiforme, Tetraedron,* common; various diatoms; *Rotifer,* an elongate species; *Merismopœdia glauca; Cœlastrum,* Desmids.

Sample 7. August 21, 1908. A small amount of rather coherent fine flocculent greenish material. *Peridinium tabulatum,* very common; *Anuræa cochlearis,* a few; *Microcystis æruginosa,* frequent; *Lyngbya æstuaria,* short filament; *Pediastrum boryanum, Cocconema cymbiforme, Cymatopleura, Epithemia argus, Gomphonema, Synedra, Tetraedron, Scenedesmus,* occasional; *Dinobryon, Staurastrum,* rather slender form.

Sample 8. August 20, 1908. A small amount of flocculent bluish material. *Peridinium tabulatum,* most abundant; *Cœlosphærium kuetzingianum; Pediastrum duplex, Microcystis æruginosa, Anuræa cochlearis,* Sponge spicule, Diatoms (*Navicula, Cocconema,* etc.), *Scenedesmus.*

Sample 9. August 20, 1908; a fair amount of flocculent grayish brown material with a greenish cast. *Peridinium tabulatum,* most abundant; *Microcystis æruginosa, Anuræa cochlearis, Staurastrum, Pediastrum duplex, Botryococcus braunii; Tetraedron minimum, Cœlosphærium kuetzingianum; Pediastrum boryanum, Chydorus, Lynbya æstuarii, Gloeocupsa,* Diatoms—*Cocconema cymbiforme, Navicula.*

3. *Unio gibbosus* Barnes.

This mussel, known among clammers as the "spike" or "ladyfinger" is, next to *Lampsilis luteola,* the most abundant shell in the lake.

It is found wherever the other mussels are; that is, in sandy or somewhat marly bottom in rather shallow water most of the way around the lake, and in the shell-bed in Lost Lake below Bardsley's. In Lake Maxinkuckee one of the best beds is at Long Point. It is abundant also at Norris Inlet, and by McDonald's and Farrar's.

No very young of this species were found in the lake; they are, however, hard to find in numbers anywhere, even in rivers where the species is abundant—except in cases where portions of the river go almost dry, and this of course never happens to the beds in the lake. The half-grown examples are solid, rather cylindrical shells, the same neat form that is known as the "spike" among the clammers. The old shells develop into a peculiar form, being flattened, arcuate along the ventral border and very thin posteriorly, so that they usually crack badly in drying; they represent the form described by Simpson as var. *delicata*. In general outline they remind one somewhat of *Margaritana monodonta*. This form is not strictly confined to the lake; some similar shells were collected in the Wabash near Terre Haute.

As found in the lake, *Unio gibbosus* is very constant in its characters, the only noteworthy difference between individuals being the change in shape already referred to as being due to age. In rivers this shell exhibits considerable variation in shape, size, color of nacre, etc., but the shells of the lake are quite constant in almost every respect. The nacre is a deep purple, never varying to pink or white as it frequently does in rivers.

Like *Lampsilis luteola* this species is frequently preyed upon by muskrats and the cleaned out shells are common where these rodents have had their feasts.

Although *U. gibbosus* of the Tippecanoe River near the mouth of the Outlet are very commonly infested with a distomid parasite along the hinge-line which brings about the formation of irregular baroques, this parasite does not occur in the lake so far as known. Small species of *Atax* are common parasites of this species in the lake, and in 1909 one was found affected by the large *Atax ingens*.

Even the large strong river shells of *Unio gibbosus* have as yet no value in the manufacture of buttons because of their purple color, and lack of luster. (The white-nacred shells are sometimes used.)

The only other lake examples with which the Lake Maxinkuckee specimens of this species have been compared, are some collected in Lake Erie at Put-in-Bay. The Lake Erie shells are much unlike the Maxinkuckee specimens, being short, humped and remarkably solid and heavy. Similar shells to those of Lake Erie are found in some of the small southern rivers.

We have no notes referring to gravid examples in the lake. This was probably because the most active work in collecting and examining mussels was carried on in the autumn, and the breeding period of this species is in early summer.

4. *Alasmidonta calceola* (Lea).

Judging from the dead shells found scattered along shore, this is not a particularly rare species in the lake. The shells were found most abundantly along the north shore of the lake, although they were also found along the east and southeast portion and were not infrequent between Arlington and Long Point. No living examples were found. On account of its small size and its habits, this is a rather difficult species to find, even where common, except under favorable conditions such as exceptionally low water, when the mussels move about more or less. Nothing was therefore learned of its habits in the lake. In the Tippecanoe River near Delong, Ind., this species was rather common in stiff blue clay near shore, and it is fairly abundant in Yellow River at Plymouth. Here, although the dead shells were common, the living examples were difficult to find until, during a period of very low water, they began actively moving about and could be tracked down. The species, which reaches an unusually large size in Yellow River, was there found gravid in autumn (September and October). The glochidia are of the Anodonta type, chestnut-shaped or rounded-triangular in outline, with large hooks at the ventral tips of the valves.

5. *Anodonta grandis footiana* (Lea).

Although the genus *Anodonta* is generally regarded as the "Pond-mussel" *par excellence*, the species of which might naturally be expected to be at home in lakes and ponds and thrive in such places even better than in rivers, the Anodantas of Lake Maxinkuckee show, along with the river species proper, the dwarfing influence of the lake. Moreover, *Anodonta* is not as one might naturally expect, the most abundant mussel in

the lake, but is outnumbered, in some beds at least, by both *Lampsilis luteola* and *Unio gibbosus*. Its relative scarcity in some of the shore beds is in part made up by its wider distribution in the deeper waters of the lake than the others reach, and on its presence on the isolated bars, where it was occasionally taken up by the dredge.

On account of the great variability of *Anodonta grandis* and the difficulty in distinguishing the various forms, particular attention was paid to this species as found in the lake, and the lake specimens were compared with numerous examples from the neighboring lakes and river. No Anodontas were found in the Tippecanoe River near Lake Maxinkuckee Outlet, and we were therefore unable to compare our lake specimens with the form that would be most interesting in this connection.

The mussels of Tippecanoe Lake at the head of Tippecanoe River were examined in this connection. Blatchley (Indiana Geological Report for 1900, p. 190) has reported *Anodonta grandis* as common, and the subspecies *footiana* as frequent in Tippecanoe Lake. The Anodontas of that lake differ markedly both in the size and shape of the individuals from those of Lake Maxinkuckee. The difference in size can be easily explained by the more favorable conditions in Tippecanoe Lake. This body of water is more fluviatile than Lake Maxinkuckee, being directly connected with the Tippecanoe River, which is already a fairly large stream when it leaves the lake, and the mussel beds of the lake and river are continuous. The upper part of Tippecanoe Lake is exceptionally favorable for Anodontas; the living mussels are large and abundant, and the dead shells almost pave the bottom near shore, several dead shells often being telescoped within each other. Some of the shells reached a size not often surpassed in the neighboring rivers; one example measuring 172.5 mm. long, 95 mm. high and 65 mm. in diameter. A few were thickened with a tendency to form half pearls, or "blisters", but most were thin. A number of the shells approached *Anodonta corpulenta* in general form, and one flattened, rounded shell resembled *A. suborbiculata*. The Anodontas from other lakes of the Tippecanoe River system, such as Center Lake and Eagle Lake near Warsaw, resemble those of Lake Maxinkuckee, but are generally smaller and shorter.

The Anodontas of Lake Maxinkuckee were also compared with those of Yellow River a few miles to the north, and with the various lakes

of the Kankakee system, including Upper Fish Lake, Lake of the Woods (Marshall Co.) Pretty Lake, Twin Lakes, Bass Lake and Cedar Lake. Some of the Yellow River Anodontas were normal, oval shells such as are common in the rivers of Northern Indiana; a few were exceptionally thin and exceedingly inflated, resembling *A. corpulenta.* Those of Upper Fish Lake—originally a fluviatile lake containing other fluviatile shells such as *Q. undulata*—were large shells like those of Tippecanoe Lake. The Anodontas of each of the other lakes differed more or less from those of the others, though all probably had a common origin. The only lake of this group the Anodontas of which closely resembled those of Lake Maxinkuckee is Bass Lake, and even there the shells were somewhat different, being smaller and with the epidermis more deeply stained. Even the Anodontas of Lost Lake differ slightly from those of Lake Maxinkuckee, being somewhat more inflated and with the epidermis green rather than brown, and in having the shell usually somewhat thinner. Some of the shells near the outlet of Lost Lake are exceedingly thin, some of them so much so that ordinary print can easily be read through them; they are so fragile that it is almost impossible to keep them.

Of the collection from Lake Maxinkuckee, mostly from Long Point, 26 examples were carefully compared. The smallest measured 68 mm. long, 38 mm. high and 24.6 mm. in diameter, and the largest 93.5 mm. long, 50 mm. high and 37 mm. in diameter. Among variant forms was one female, gravid when collected, which was unusually elongate, its measurements being 86 mm. long, 43.5 mm. high and 32.5 mm. in diameter. In outline this shell closely resembled *Anodontoides ferussacianus subcylindraceus.*

Some of the larger specimens are rather humped and arcuate, the ventral margin of one being somewhat concave. This is a variation which is quite likely to occur in old shells of any species.

Although gravid Anodontas were found rather frequently during the late autumn, no infected fishes were seen, and no young were found.

The Anodontas of the lake are fairly free from parasites, a few *Atax* and *Cotylaspis* and occasionally a few distomids on the mantle next to the umbonal cavity being the only ones present in any numbers. In some of the other lakes the Anodontas were very badly infested; a colony found in one of the Twin Lakes being infested to a remarkable

degree by a distomid which formed cysts in the margin of the mantle.

Food and Parasites of Various Examples.—The following is the result of the examination of various examples of Anodontas: Sample No. 10. Vial containing intestinal contents of *Anodonta grandis footiana*, Lost Lake, September 7, 1908. The vial contains a considerable amount of material (in formalin) which was separated into black fine mud below and fine flocculent light green above. Upper portion—*Microcystis æruginosa*, most common; *Peridinium tabulatum*, some; *Pediastrum boryanum; Melosira crenulata*, a few filaments; *Cœlastrum microporum*, *Botryococcus braunii* and *Scenedesmus*. Bottom layer—*Lyngbya æstuarii*, *Microsystis æruginosa*, very common; *Peridinium tabulatum*, *Anuræa cochlearis*, *Cocconema cymbiforme* and *Navicula*.

Sample No. 11. Food of *Anodonta grandis footiana*, Lake Maxinkuckee, near Norris Inlet, August 20, 1908. A good mass of flocculent fine green material; no mud.

Microcystis æruginosa, most common, *Melosira*, filament, *Oscillatoria*, short filament; *Anuraea cochlearis*, several; *Cocconema cymbiforme; Gomphosphæria aponina; Peridinium tabulatum; Cœlosphærium keutzingianum*, *Lyngbya æstuarii*, *Epithemia argus*, *Chydorus*, and what appears to be fragments of *Ceratium hirundinella.*

Sample No. 12. *Anodonta grandis footiana*, near Norris Inlet, Lake Maxinkuckee, August 20, 1908; a small mass of flocculent blue material.

Microcystis æruginosa most abundant; *Lyngbya æstuarii*, *Melosira*, *Epithemia*, *Anuræa cochlearis*, *Pediastrum boryanum*, *Cosmarium intermedium* and a few others, *Staurastrum* sp?, *Spirulina* and *Pediastrum duplex*.

Sample No. 13. *Anodonta grandis footiana*, 97 mm. long. Edge of Lake Maxinkuckee east of Norris Inlet, August 29, 1908.

Parasites; 9 *Atax*, free among gills. Mussel gravid, with anterior end of shell indented and with some brown spots on the nacre. Food mass fine golden brown, abundant in quantity, containing *Anuræa cochlearis*, many; *Microcystis æruginosa*, most abundant element; *Lingbya æstuarii*, frequent; *Scenedesmus*, a few; *Botryococcus braunii*, frequent; *Cocconema cymbiforme; Staurastrum, Navicula; Fragilaria; Chydorus*, a few; *Cœlosphærium kuetzingianum;* the diatoms are not abundant.

Sample No. 14. *Anodonta grandis footiana* apparently old, 90 mm.

long, near Norris Inlet, Lake Maxinkuckee, Ind., August 29, 1908, the shell stained somewhat brown inside, with one steel-blue stain on the right valve anteriorly.

Parasites; *Atax* 7, large, full of eggs, one small, one very small, these all free among the gills; *Cotylaspis insignis* 1, in axil of gill.

Food abundant; *Microcystis æruginosa*, abundant; *Lyngbya æstuarii*, common; *Pediastrum duplex, Botryococcus braunii*, a few; *Cosmarium; Anuræa cochlearis*, several; *Scenedesmus; Ankistrodesmus*, and many diatoms, among which are *Cocconeis pediculus, Melosira, Gomphonema, Navicula, Epithemia turgida*, etc.

Sample No. 15. *Anodonta grandis footiana*, 101 mm. long, Lake Maxinkuckee, near shore, by Norris Inlet. August 29, 1908.

Parasities; 5 *Atax*, free in gills, some full of eggs, 2 smaller in size, larval *Atax* (black) scattered in gills. *Cotylaspis insignis*, 2, axil of inner gill.

A large amount of food material in intestines, very fine, of a yellowish brown color.

Microsystis æruginosa, Anuræa cochlearis, Lyngbya æstuarii, Botryococcus braunii Cœlosphærium keutzingianum, Cosmarium, Navicula, an elongate form, *Cocconema cymbiforme, Pediastrum duplex, P. boryanum;* red cysts apparently of *Peridinium.*

Sample No. 16. *Anodonta grandis footiana*, 90 mm. long, sandy bottom of Lake Maxinkuckee near Norris Inlet. August 29, 1908. Mussel gravid. Parasites: *Atex*, 3, free among gills, *Atex* embryos scattered through gills.

Food material scarce, fine golden brown in mass, consisting of *Microcystis æruginosa*, abundant; *Cœlosphærium keutzingianum*, abundant; *Lyngbya æstuarii*, a few filaments; *Anuræa cochlearis* and another rotifer; *Botryococcus braunii; Sorastrum, Cœlastrum, Scenedesmus, Pediastrum duplex, Navicula*, several; *Melosira tabulata, Synedra, Epithemia turgida, Cocconema cymbiforme;* and other small diatoms rather numerous. *Cosmarium*, a few.

Sample No. 17. *Anodonta grandis footiana*, 93 mm. long, sandy bottom of Lake Maxinkuckee near Norris Inlet, August 28, 1908. Mussel gravid. Parasites: 1 *Atax*, free among gills. Intestines almost empty. *Microcystis æruginosa*, one of most abundant elements; *Lyngbya æstuarii, Cœlosphærium kuetzingianum, Botryococcus braunii;*

Cosmarium, Pediastrum, Cocconeis pediculus, Epithemia turgida; Navicula (1 actively moving), *Gomphonema, Melosira tabulata, Anuræa cochlearis, Chydorus.*

Sample No. 18. *Anodonta grandis footiana,* 95 mm. long. Lake Maxinkuckee near Norris Inlet, August 29, 1908. Mussel gravid. Parasites: 6 *Atax* free among gills, one a minute red species. Many young Atax embryos in inner side of mantle, not in gills.

Food material golden brown, with some green intermixed, very fine. *Microcystis æruginosa,* common; *Lyngbya æstuarii,* a few filaments; *Cœlosphærium keutzingianum; Botryococcus braunii; Pediastrum duplex; Anuræa cochlearis* a few; *Epithemia turgida; Navicula,* common; *Cocconema cymbiforme; Cocconeis pediculus,* several; *Cosmarium; Chydorus.*

Sample No. 19. *Anodonta grandis footiana,* Lake Maxinkuckee, near Winfield's. Mussel gravid. Parasites: Young *Atax* in gills; Distomids on mantle (a slug pearl near hinge.)

Food: *Botryococcus braunii; Microcystis æruginosa; Lyngbya æstuarii, Cœlosphærium kuetzingianum, Pediastrum duplex, Navicula, Cocconema cymbiforme.*

Sample No. 20. *Anodonta grandis footiana.* Lost Lake. Young transparent shell, gravid, length 77 mm., height 41 mm., diameter 30 mm., live weight 1 oz., shell 1-4 oz. Parasites, several *Cotylaspis insignis* in axil of gills, food chiefly *Microcystis æruginosa;* considerable *Botryococcus braunii.*

Sample No. 21. *Anodonta grandis footiana,* Lost Lake. Parasites: 1 young *Atax* in gill; *Cotylaspis insignis* in axil of gill. Food chiefly *Microcystis æruginosa,* a little *Botryococcus braunii, Lyngbya æstuarii* and *Pediastrum boryanum.*

6. *Strophitus edentulus* (Say). Squawfoot.

Not very common in the lake. Occasional shells can be picked up along shore, especially between Long Point and Arlington, and along the north shore. Living examples were also taken in small numbers from the mussel bed at the mouth of Norris Inlet, and at Long Point. In a collection of about 300 living mussels collected at the latter place in the autumn of 1907, only three were of this species.

As found in the various rivers of the country, this is one of the

most variable of shells, and the exact limits of the species and its various forms are not yet well worked out. The lake examples, though differing considerably from those of the neighboring rivers and from river shells in general, do not exhibit a very large range of variation. They are all markedly dwarfed, the average length being about 2 1-2 inches or 63.5 mm. All have a well-developed rounded posterior ridge. The epidermis is deeply stained, that of the exposed portion of the shell being a rich yellowish brown, while the anterior portion, in the living shell buried in the soil of the bottom, is a deep shining brown black. The anterior margin is not nearly so heavy and produced as one frequently finds it in river examples. The beaks of the lake shells are not so angular as they usually are in river shells, and the high wavy ridges are more numerous and pronounced. In the Maxinkuckee shells, also, a number of fine hair-like lines or ridges, much like growth lines, extend along the posterior border of the umbone, parallel with the posterior ridge of the earlier stages of the shell.

The nacre of the lake shells is a rich rosy salmon. Unlike the salmon color of "*Anodonta salmonea*", this is a natural color, not due to diseased conditions; the nacre surface is very smooth and the color extends deeply into the shell. In some cases the inner nacreous surface appears to be a secondary thickening of the shell, laid on the older portions like an enamel. Below this extra nacreous deposit the growth lines are very distinct on the inner surface of the shell. The rest periods are distinct black lines, often plainly visible through the translucent shell when held up to the light. Rays are always invisible by reflected light in the lake shells, but in some examples they were visible by transmitted light. The animal has orange-colored flesh. The few living examples examined indicate that parasites are common; one contained three old *Atax ypsilophorus*, and several young.

One gravid example was found, October 17, 1907. The youngest example found was 42 mm. long and exhibited four rest periods.

7. *Lampsilis glans* (Lea).

Fairly common in the main lake; dead shells are often found along shore, and occasionally the living mussels are to be seen in shallow water at the various mussel beds at the lake. It is quite abundant along the edges of the thoroughfare joining the lakes, and is common in Lost Lake.

The examples found in the thoroughfare and Lost Lake were of unusually large size; this is one of the few species of mussels which are as large or larger in the lake than in the neighboring rivers. *L. glans* appears to prefer shallow water along shore. A good number of shells recently cleaned out by muskrats was found near the water's edge at Long Point in the late autumn of 1913.

In the Tippecanoe River at Delong this was a very abundant species in the greasy whitish blue clay along shore, and was here one of the favorite morsels of the muskrat. With the exception of *Micromya fabalis* this is the smallest species of mussel found in the lake. It can be easily recognized by its black epidermis, small size and purple nacre.

8. *Lampsilis iris* (Lea).

Rather common in the lake in shallow water near shore, found scattered among the other species in the various shell-beds. There is a good colony in the Lost Lake bed, and it is fairly abundant off the Depot grounds, by Kruetzberger's pier, at Long Point, and at the bed near the mouth of Norris Inlet.

The lake shells differ markedly from those of the neighboring rivers so much that it is easy to separate the lake and river shells at a glance. The lake shells are considerably more elongate, and the epidermis is stained a deep brown, mostly concealing the rays; when these are visible they are brownish rather than green, and the umbones are rather eroded. The shells, indeed, resemble somewhat the males of *L. subrostrata*, with which they are associated. The lake shells exhibit a tendency to have their posterior margin somewhat broader than the river shells, and the shells are flatter at the posterior tip, becoming somewhat produced. The river shells are more solid and heavy.

Lampsilis iris is one of the few species of mussels which does not show a marked decrease of size in the lake; indeed, some of the larger lake examples run actually larger than those from the neighboring rivers. Some of the largest lake shells examined have the following dimensions:

No.	Length mm.	Alt. mm.	Diam. mm.
1	69.6	37.3	21.0
2	65.9	34.9	21.0
3	68.0	34.6	22.0

No.	Length mm.	Alt. mm.	Diam. mm.
4	64.9	35.8	22.7
5	67.0	36.8	20.9
6	67.7	33.8	21.5

No young shells were found, even the smallest appear rather old. The smallest three measure:

Length mm.	Alt. mm.	Diam. mm.
41.4	21.2	12.5
38.9	21.5	12.5
37.0	20.0	12.3

For comparison with the lake shells, the dimensions are given of the largest two shells found in Yellow River:

No.	Length mm.	Alt. mm.	Diam. mm.
1	67.0	34.5	22.9
2	64.0	33.5	21.0

Only one gravid example was found; this was obtained at Lost Lake bed September 7, 1908.

Of all the species of mussels in the lake, *L. iris* has the best connection, through scattered individuals along the Outlet, with the shells of the Tippecanoe River, a few shells having been found almost through the whole length of the Outlet. The Outlet shells, like those of the rivers, are brightly rayed. The species is abundant in the Tippecanoe River at Delong. A number of examples were noted in spawning condition there in late August and early September in 1908. Observations in the Maumee River indicate that this species, *L. parva* and *L. multiradiata*, do not have exactly the same breeding season as many other species of *Lampsilis* (*luteola, recta, ligamentina,* etc.), but are sometimes fertilized in July, spawning in August and September. Being small and an early developing species, it is probable that they have somewhat different habits; indeed, it is possible that they have more breeding seasons per year than the other species.

The Tippecanoe mussels of this species were a favorite food of the muskrat, and were killed in great numbers every autumn, the dead shells being thickly strewn along the bank, or piled in heaps at the bases of rocks which the rodent used as a feeding place.

Lampsilis iris has a well marked tendency in the lakes and Outlet to produce pearls and baroques; but these are too small to be of any value.

9. *Lampsilis subrostrata* (Say).

Lampsilis subrostrata reaches its best development along the muddy shores of lagoons, not being perfectly at home either in swiftly flowing streams or in perfectly quiet lakes, although occasional examples may be found in either. It is considerably more abundant in Lake Tippecanoe and Upper Fish Lake than in any other Indiana lakes examined. Along the edges of the Mississippi sloughs it is fairly common and reaches a large size, often distinguished with difficulty from *Lampsilis fallaciosa* except for the thinness of the shell and the black epidermis. It is rare in Lake Maxinkuckee, only a few examples having been obtained from the mussel bed near Norris Inlet. It is much more common in Lost Lake in the large bed along shore south of the Bardsley cottage. Mr. Blatchley, in a short report on the mollusks of the lake (25th annual report, Department of Geology and Natural Resources of Indiana, 1900, p. 250), says of this species: "Not common in the main lake; more so in the muck and mud along the margins of Lost Lake, where a well-marked variety, with a larger and broader beak, was taken. A specimen of this was sent, among others, to Mr. Chas. T. Simpson, of the Smithsonian Institution, for verification. In his reply he says: 'The variety of *subrostratus* which you send is, so far as I know, confined to northern Indiana. It is quite remarkable, and would seem to be almost a distinct species. I have seen quite a number of specimens of it, and at first thought it a variety of *U. nasutus*, but there seem to be intermediate forms connecting it with *U. subrostratus*.' "

With the exception of the differences due to sex, all the Maxinkuckee and Lost Lake shells are very uniform in appearance, much more so than *L. luteola*, and are hardly distinguishable from examples from Lake Tippecanoe, Upper Fish Lake, or a specimen collected in the Wabash River at Terre Haute by Dr. J. T. Scovell. They are dark brown in color with very faint rays. The species appears to be rare in the Tippecanoe River at Delong. One example was obtained there, which is somewhat shorter and stouter than those of the lake, and not so badly stained; it shows faint rays posteriorly. The Lost Lake shells are some-

what larger than those found at the other lakes. No young were found, the smallest shell obtained being a half-grown example. One gravid specimen was found at Lost Lake September 7, 1908. The marsupium closely resembles that of *L. iris*, being a kidney shaped mass filling the hinder portion of the outer gill, this mass marked into segments by rather deep radiating furrows. The very edge of the marsupium is white, beyond the dusky submarginal area, the white making a chain-like area at the edge of the gill. Like *L. iris*, this species has a tendency to form pearls, but they are too small to be of any value.

Food of individuals: The following is the result of the examination of the contents of the intestines of *L. subrostrata* from Lost Lake at various dates.

Sample 22. August 20, 1908. A small amount of flocculent bluish-gray material. *Peridinium tabulatum*, abundant; *Microcystis æruginosa*, abundant; *Anuræa cochlearis; Pediastrum boryanum;* Diatoms—*Synedra; Cocconema cymbiforme.*

Sample 23. August 20, 1908. A very small amount of flocculent grayish material. *Peridinium tabulatum*, a few; *Microcystis æruginosa*, a little; *Pediastrum boryanum; Cosmarium; Tetraedron minimum; Scenedesmus; Euglyphia alveolata; Peridinium*, a small, sharp-spined form. Diatoms make up the greater part, including *Cocconema cymbiforme; Navicula; Fragilaria; Coscinodiscus;* and *Epithemia.*

Sample 24. September 7. A large amount of material, black mud below, greenish flocculent material above. The upper portion contains chiefly *Botryococcus braunii* and *Microcystis æruginosa.* Bottom portion—*Microcystis æruginosa*, common; *Botryococcus braunii; Peridinium tabulatum; Peridinium*, a small-spined species; *Scenedesmus*, frequent; *Staurastrum; Pediastrum duplex; Cœlastrum*, a few; *Anuræa cochlearis; Tetraedron; Docidium; Cœlosphærium kuetzingianum;* Sponge spicule; *Lyngbya æstuarii;* Diatoms, *Synedra; Navicula; Gomphonema;* etc.

10. *Lampsilis luteola* (Lamarck). Fat Mucket.

Lampsilis luteola is the most widely distributed of the American *Unionidæ*, its range extending over nearly all of North America east of the Rocky Mountains. It lives and thrives under a great variety of conditions, being frequent in both lakes and rivers.

In Lake Maxinkuckee this is the most common mussel, being found almost everywhere in water from 2 to 5 or 6 feet deep where the bottom is suitable. It prefers a rather solid bottom with some admixture of sand or gravel, but occurs also even where the bottom is of a rather firm peaty nature as in some places in Outlet Bay. It is, however, rather scarce and widely scattered in such localities. The best beds are found at Long Point, at Farrar's, in front of McDonald's, by the old Kruetzberger pier, and in Aubeenaubee Bay off from the Military Academy. In Lost Lake it was abundant in the large mussel bed below the Bardsley cottage, and a few shells were found in the north end of the lake.

The Lake Maxinkuckee shells are smaller and thinner than those of the rivers; they closely resemble those of most of the neighboring lakes with which they were compared, such as Twin Lakes, Pretty Lake, Bass Lake, etc. The *L. luteola* of Upper Fish Lake are much larger and more like river shells. Compared with specimens of more remote lakes, those of Lake Erie are much smaller, more solid and not stained, the rays being quite distinct. The *L. luteola* of Lake Pokegama, Minn. are unlike any of those above cited, being large, thick and heavy, furnishing excellent button material.

Lampsilis luteola is represented in Lake Maxinkuckee and Lost Lake by two forms; although these forms are well connected by intergrades the extremes are pretty markedly distinct.

The colony in Lost Lake is composed of compressed, elongate shells, almost as large as those found in rivers, but considerably thinner. It is in the females of this group, and only in part of them, that the greatest variation occurs. The males are not much unlike the ordinary well-known form of the neighboring rivers. The most strongly aberrant females are markedly compressed, and flare out broadly in the post-basal region. The umbones are far forward and they remind one somewhat in contour of the marine species, *Modiola plicatula.* Some of them closely resemble *Lampsilis radiata* of the Atlantic drainage. The Lost Lake mussels of this species are stained a peculiar attractive ash-gray which does not greatly obscure the rays. They are not so heavily encrusted with marl as are those in the Lake Maxinkuckee beds. Typical Lake Maxinkuckee specimens are dwarfed and stained a deep brown, which obscures the rays. Most of them are thickly-coated posteriorly

with incrustations of marl. It is principally this species which has associated with it the little water-beetle, *Stenelmis sulcatus* Blatchley. At Long Point, where *L. luteola* is the most common mussel, examples of the peculiar Lost Lake form are rather frequent. In comparing sets of shells from the various mussel beds of the lake, Long Point, Farrar's and the Norris Inlet beds, it was noted that the mussels of each bed, as one approached the upper portions of the lake, averaged somewhat smaller.

As regards food, movements, reproduction, etc., *L. luteola* does not differ greatly from the other mussels of the lake with the exception that it appears to be considerably the most active species in the lake. A few more were observed moving about during the winter of 1900-1901. The deep water individuals rarely move about at all. In the autumn of 1913 the migration of those near shore into deep water was strikingly shown in a series of numerous furrows, with a mussel at the deep water end and extending from shore outward near Long Point.

As with the other mussels of the Lake, reproduction is a rather inconspicuous phenomenon, not attended with the marked display common in the larger river examples. Of 252 examples collected at Long Point, October 17, 1907, 25 contained glochidia in the gills, some being very full and much distended. One was found gravid May 24, 1901, and on August 22, 1906, some in Lost Lake appeared to be about ready to spawn.

The young of this species were found rather frequently in the lake, much more frequently, indeed, than any other kind. The smallest examples were obtained while seiving sand for Sphæriums at Long Point. These young mussels live buried in the fine sand near shore. Specimens up to about a half-inch long are very crinkly, being covered with narrow elevated parallel ridges, generally five in number, each consisting of two open loops placed end to end, the sides of the loops being roughly parallel with the ventral margin of the shell; the ends where they join form a sharp curve upward toward the umbone. These double loops are followed by a number of broken irregular ridges. The markings just described persist on the umbones of the older shells until eroded away. The half grown shells are beautifully rayed with green on a whitish background. As the shells grow older they become gradually stained a deep uniform brown, obscuring the rays.

Most of the mussels of the lake are slightly parasitized, none abundantly; they contain a few examples of a small reddish *Atax*, and a few *Cotylaspis insignis*. A small round worm, somewhat like a vinegar eel, was found very active in the intestine of one specimen; it was probably parasitic.

Small irregular pearls or slugs are produced but they are of no value. In some rivers this species produces an abundance of small round pearls. Some of the pearl-bearing river specimens were planted in the lake in 1912 to see if they would infect the lake shells.

The *Lampsilis luteola* of the rivers is a fair button shell, but the Lake Maxinkuckee shells are too small and thin to have much value. It is a remarkable fact that in Lake Pokegama, Minn., *L. luteola* grows abundantly in shallow bottom among the weeds, and there produces a handsome thick heavy shell, one, indeed, concerning which the pearl button manufacturers are very enthusiastic, so much so that the shells at that distant point from the market brought $22.00 per ton; in the summer of 1912, two carloads of these shells were shipped to Europe.

Just why the Lake Maxinkuckee shells are not like the excellent ones of Lake Pokegama remains as yet unanswered, but seems to be largely a question of breed. It would certainly be worth while to introduce the Lake Pokegama breed into Lake Maxinkuckee.

Following is the results of the examination of various individuals of the Maxinkuckee and Lost Lake shells:

Sample 25. *L. luteola.* Lost Lake, September 7, 1908. Mussel gravid. Length 100 mm., altitude 62 mm.; diameter 33 mm. Live weight 2½ oz.; shell 1¾ oz. Parasites: 7 free *Atax* among gills, young *Atax* in gills and numerous *Atax* eggs on interior surface of mantle. Food chiefly *Microcystis æruginosa; Botryococcus braunii, Lyngbya æsturaii; Melosira; Navicula.*

Sample 26. *L. luteola.* Lost Lake, September 7, 1908: Mussel gravid: Length 95 mm., alt. 60 mm., diam. 38 mm. Live weight 3¾ oz.; shell 1¾ oz. Parasites: 7 free *Atax* in gills, and *Atax* eggs in the mantle. Food, chiefly *Microcystis æruginosa;* also *Botryococcus braunii; Navicula; Lyngbya æstuarii;* and *Anuræa cochlearis.*

Sample 27. *L. luteola.* Lost Lake by Bardsley's September 7, 1908. Live weight 3¼ oz.; shell 1½ oz., length 97 mm., alt. 54 mm., diam. 33

mm. Parasites: 7 free *Atax* among gills. Many small red eggs of *Atax* on inner surface of mantle. Food chiefly *Microcystis æruginosa; Botryococcus braunii;* and *Navicula.*

Sample 28. *Lampsilis luteola.* Lost Lake, September 7, 1908. Live weight 3¾ oz.; length 104 mm., alt. 54 mm., diameter 33 mm. Parasites: *Atax* 6, free among gills, eggs of *Atax* on inner side of mantle, young in pits on side of foot. Food, *Microcystis æruginosa,* most common; *Lyngbya æstuarii; Navicula; Melosira; Anuræa;* and *Cocconema.*

Intestinal contents of two examples of *L. luteola* obtained in Lake Maxinkuckee August 27, 1908, near the shore just north of the ice office gave the following results:

Sample 29. *Microcystis œruginosa,* main mass; *Anuræa cochlearis,* a few; *Botryococcus braunii,* rather common; *Cocconema cymbiforme,* one; *Lyngbya æstuarii,* 1 filament; *Navicula,* 2 examples; *Synedra,* a few.

Sample 30. *Microcystis æruginosa,* main mass; *Botryococcus braunii,* very common; *Lyngbya æstuarii,* several filaments; *Anuræa cochlearis,* a few; *Synedra,* some; *Navicula,* one example very lively; *Cosmarium,* one; Round worm like vinegar eel, very lively.

Sample 31. Lost Lake, 1908. A good mass of material, blackish below, flocculent greenish above. *Lyngbya aestuarii,* a few filaments, *Microcystis æruginosa,* quite abundant; *Anuræa cochlearis;* sponge spicule; *Pediastrum duplex; Staurastrum; Botryococcus braunii; Peridinium tabulatum,* a few; *Peridinium,* a small spiny species 1; *Pediastrum boryanum;* several diatoms—*Navicula; Coscinodiscus; Melosira; Cocconema cymbiforme; Microcystis,* is the most abundant element; *Peridinium* is rather scarce.

Sample 32. Lake Maxinkuckee, August 27, 1908: A small amount of brownish green flocculent material. *Anuræa cochlearis,* quite frequent; *Lyngbya æstuarii,* short filament; *Peridinium tabulatum,* a few; *Cœlastrum microporum; Cœlosphærium kuetzingianum; Pediastrum boryanum; Scenedesmus,* very few; *Chydorus,* fragment. Diatoms, *Epithemia turgida; Navicula; Cocconema cymbiforme; Gomphonema; Coscinodiscus.*

Sample 33. Lake Maxinkuckee, August 27, 1908: A fair amount of brownish green material, muddy below, flocculent green above. The

green top material consisting chiefly of *Microcystis æruginosa;* with some *Anuræa cochlearis; Lyngbya æstuarii, Microsystis æruginosa; Bulbochæte,* bristle; *Cœlastrum microporum; Merismopœdia glauca; Pediastrum boryanum;* Diatoms—*Navicula, Coscinodiscus;* etc.

Measurements:—

The following is a series of measurements of Lost Lake examples:

Measurements in mm.

No.	Date, 1908.	Length.	Alt.	Diam.	Remarks.
1189	Aug. 20.	85.	54.	32.	Fanshaped female.
1260	Sept. 7.	97.4	55.	31.	Fanshaped female gravid.
1215	Aug. 20.	87.	46.	35.6	Fanshaped female.
1224	Aug. 20.	98.	56.	26.	Fanshaped female.
1245	Aug. 20.	90.	51.	32.8	Fanshaped female.
1235	Aug. 20.	98.	48.9	36.3	Male.
1188	Aug. 20.	102.	53.	36.	Male.
1221	Aug. 20.	100.	51.	37.	Male.
1223	Aug. 20.	96.	51.4	34.8	Male.
1228	Aug. 20.	102.3	53.7	33.	Male.
					Most of these shells. blistered posteriorly.

The males are fairly like those of river examples; the females are more fan-shaped. Weight of the 10 shells, 15 oz.; only a few are rayed.

11. *Lampsilis ventricosa* (Barnes). Pocket-book.

Rather common at the Long Point mussel bed; a few found in the bed by Farrar's and a few in Lost Lake. The species as found in the lake is markedly dwarfed and quite different in appearance from the usual river form. There are two types in the Long Point bed, one consisting of females and having the post-basal inflation of the shell characteristic of that sex, not exactly as in the river form, however, but somewhat more restricted; this feature, along with a peculiar stain of the epidermis which conceals the normal coloring of the shell, causes them to resemble very closely a short female *L. luteola.* The other type, an oval shell without the post-basal inflation, was at first taken to represent the males, but some of them were found to contain glochidia. These, too, bear a marked resemblance to *L. luteola,* and the only way

to distinguish the two species, as they occur in the lake, was by an examination of the umbonal sculpture. This in *ventricosa* consists of a a few coarse parallel ridges; in *luteola* the sculpture is of numerous fine wavy lines.

The lake *L. ventricosa* was so markedly different from the species as usually known that it was compared with a large series of both lake and river forms. Of river shells only a few from the central part of the Maumee, where for some reason the shells are markedly dwarfed, bore any close resemblance to it. None was found in any of the neighboring lakes with which to compare them. In some of the small lakes of Michigan where Dr. Robert E. Coker had collected he had experienced a similar difficulty in distinguishing between *L. ventricosa* and *L. luteola* and had sent sets of critical specimens to Mr. Bryant Walker of Detroit, Mich., who identified the shells with a few coarse straight undulations on the beaks as *Lampsilis ventricosa canadensis* and the others as *L. luteola.*

The Maxinkuckee specimens were also compared with *L. ventricosa* from Lake Champlain, and were found to be much like them. The Champlain examples which were free from staining of the epidermis more closely resembled in color the *ventricosa* of the rivers.

The specimens of *L. ventricosa* differed considerably in the different beds. Lost Lake examples are usually rather small, and are stained a peculiar ashy-gray. Those from the beds near Farrar's are mostly small and apparently young and are rather well rayed; they resemble river forms more closely than any others in the lake.

The large oval *L. ventricosa* of Long Point are the heaviest shells of the lake. A peculiarity of several of these shells is a conspicuous rib-like thickening on the inside, extending from near the umbonal cavity postero-ventrally. The nacre is soft satiny in luster, and not very iridescent. This oval form of *ventricosa* found at Long Point furnishes the only shell in the lake that could be used to any advantage in the manufacture of buttons, and even it produces rather inferior material. Some of these shells were sent away to a button factory at Davenport and buttons were made of them. The following is a set of measurements of these large shells:

No.	Date, 1907.	Lgth. mm.	Alt. mm.	Dia. mm.	Remarks.
1	Sept. 24.	114.	74.8	53.	Female gravid.
2	Oct. 30.	107.6	65.5	54.8	
3	Oct. 2.	105.2	63.7	52.5	
4	Oct. 30.	92.5	60.4	53.7	Female gravid.
5	Oct. 30.	103.7	67.3	49.3	Dorsal baroques.
6	Oct. 17.	98.6	60.2	55.5	Arcuate, baroque found.
7	Oct. 20.	101.7	63.6	52.2	
8	Oct. 30.	94.6	58.4	53.2	Nacre diseased and blistered.
9	Oct. 17.	95.6	55.7	49.	
10	Oct. 17.	91.5	60.4	49.5	

Although the reproductive phase of *L. ventricosa* of the Lake is much less conspicuous than in the river mussels, most of them apparently succeed in reproducing themselves. Most of the females found later in autumn have more or less numerous glochidia in the gills. No infected fishes or very young mussels of this species were seen.

The most common parasite is *Atax*, and it is not particularly abundant. Of 6 examples collected near Farrar's July 24, 1909, the first contained 9 of the mites, the second 4, the third 15, with *Atax* eggs in mantle and body, the fourth 12 *Atax* and numerous eggs of the mite on the inner surface of the mantle, the fifth 3 *Atax* with eggs, and the sixth 7 *Atax* with eggs and egg scars. No other parasites were noted. No pearls were found, only a few irregular slugs.

In 1906 some of the immense *L. ventricosa* of Yellow River were planted in the lake near shore not far from the old ice office. A few died shortly after planting but near the same place two years later some of the mussels were found alive and apparently thriving. Two of the large females were killed and examined. Although this was at a time when this species is usually gravid, one of these individuals was sterile, apparently having failed to become impregnated. The influence of its residence in the lake was marked by a dark stain which covered the exposed portion of the shell. The other had a few eggs in the gills, and numerous marginal cysts in the mantle. About 10 *Atax* among the gills, and numerous distomids on the outside surface of the mantle in the umbonal cavity.

12. *Lampsilis multiradiata* (Lea).

Not abundant in the lake; occasional shells are found along shore, and now and then they are encountered in the piles of shells where muskrats have been feeding. A few living examples were found in the mussel bed near the mouth of Norris Inlet and a few at Long Point bed. In all hardly a dozen living examples were secured; of 563 shells taken from a pile left by a muskrat at Long Point in 1907, only one was of this species. This mussel, as it occurs in the lake, is not nearly so attractive as river specimens, being dwarfed, and so deeply stained that the rays are inconspicuous, being usually black or dull brown instead of green.

This species was found in unusual abundance in the Tippecanoe River at Delong, and a considerable number was observed spawning during the autumn of 1908. While spawning, this mussel is very conspicuous in its habits. It lies either on its back, or more usually with the posterior end directly upward, and the showy edges of the mantle, which are of a yellowish brown color, and cross-barred with narrow lines which are continuous with the fine rays of the epidermis, look a good deal like a small darter lying on the bottom. Long waving pennant-like flaps, with showy black spots at the base of each are developed, and this portion of the mussel is made still more conspicuous by reason of periodic violent spasmodic contractions.

In the Tippecanoe River near Delong this is one of the favorite foods of the muskrat, and it must be difficult for them to hold their own against that rodent.

13. *Micromya fabalis* (Lea).

Rare; previous to 1913 only one shell had been found; this was picked up on the north shore of the lake in 1907. In 1913 several shells, recently cleaned out by some animal, probably a muskrat, were found at the wagon bridge. This species is fairly common in Tippecanoe Lake and still more so in the Tippecanoe River at Delong, where it was collected in shallow water near shore in rather stiff blue clay. It is the smallest of our Unionidæ. The white or bluish white nacre has an exceedingly brilliant luster.

Several other species of mussels have been recorded for the lake, among them *Quadrula lachrymosa* (Lea), *Margaritana marginata* Say,

Unio pressus Lea, *Anodonta subcylindracea* Lea, *Anodonta imbecillis* Say, *Unio phaseolus* Hildreth, *Unio circulus* Lea, *Unio parvus* Barnes, and *Lampsilis gracilis* (Barnes). We have seen representatives of none of these species from the lake, and while some, such as *Anodonta imbecillis** and *A. subcylindracea* are very probably present, the presence of the others is very improbable.

* Since the above was written a single specimen of *Anodonta imbecillis*, from Lost Lake, has been seen.

Further Experiments with the Mutant, Scarlet, from Drosophila Repleta.

Hobart Cromwell.

The mutant, scarlet, from Drosophila repleta, was first described by Hyde in the American Naturalist, 1914, Vol. 49, p. 183. This new eye-color was found to be a recessive Mendelian unit, giving a ratio of 3 to 1 in the F_2 generation. In order to familiarize myself with Mendelism, I undertook to determine whether or not the black-eyed flies of the F_2 generation were in the ratio of one homozygous to two heterozygous as the Mendelian formula demands.

The following tables give the results of the crosses between scarlet and the wild stock. All the F_1 flies had black eyes like those of the original wild parents. These were then inbred in mass culture, as is shown in Tables I. and II.

TABLE I.

F_2 Flies of the Cross, Scarlet Female by Wild Male.

Culture Number.	Wild Type, Females.	Wild Type, Males.	Scarlet, Females.	Scarlet, Males.
1	187	202	64	59
2	425	418	123	128
3	410	410	124	90
4	211	200	67	70
5	123	152	52	38
6	190	175	64	40
7	200	210	61	58
8	115	115	43	31
Total	1,861	1,982	598	534

TABLE II.

F_2 Flies of the Cross, Scarlet Male by Wild Female.

Culture Number.	Wild Type, Females.	Wild Type, Males.	Scarlet, Females.	Scarlet, Males.
1	447	456	120	146
2	714	692	186	203
3	284	292	68	92
4	445	415	108	123
5	193	171	64	65
6	215	220	75	77
7	122	110	32	38
8	562	462	155	142
9	326	304	108	112
10	228	262	105	69
11	195	178	66	63
12	149	157	51	53
13	341	302	87	116
Total	4,221	4,021	1,225	1,299

In the F_2 generation from the scarlet female (Table I), there was a total of 3,843 wild type flies and 1,132 scarlet, which is approximately a ratio of 3 wild type to 1 scarlet. In the F_2 generation from the scarlet male (Table II), there were 8,242 of the wild type and 2,524 of the scarlet, which makes a ratio of 3.22 wild type to 1 scarlet. The extracted scarlets have since bred true.

Crosses were made to scarlet with the F_2 wild type flies from both the original cross and its reciprocal. To insure virgin flies the sexes were separated every twelve hours. These back-crosses were made in pairs to determine how many of the flies of this generation were homozygous and how many were heterozygous. If the scarlet eye-color is a simple recessive unit, all the homozygous blacks mated to scarlet should give only wild type offspring, while the heterozygous blacks mated to scarlet should give equal numbers of blacks and scarlets. The results of these crosses are shown in Tables III to VI.

Table III gives the results of back-crossing to scarlet the F_2 female wild type flies from the original parents, scarlet female by wild male. This table shows that 82 such matings were made. Of these 82 females, 27 proved to be homozygous and 55 heterozygous, a ratio of two to one. Table IV, showing the reciprocal cross of Table III, gives 18 homozygous and 59 heterozygous. Table V gives the results obtained by back-crossing to scarlet the F_2 wild type female from the original parent cross scarlet male by wild female. Of these females, 25 proved to be homo-

zygous and 39 heterozygous. Table VI, the reciprocal cross of Table V, shows a result of 14 homozygous and 16 heterozygous males.

A sum total of all the results of Tables III-VI gives 84 homozygous F_2 flies and 169 heterozygous, making a ratio of one to two, which agrees with the calculated ratio.

I am indebted to Dr. R. R. Hyde for material and helpful suggestions.

TABLE III.

P_1. Scarlet Female by Wild Male. Results of Crossing Wild Type F_1 Female Flies to Scarlet Males.

Culture Number.	Wild Type, Females.	Wild Type, Males.	Scarlet, Females.	Scarlet, Males.
1	8	9	6	9
2	17	8		
3	17	15	13	15
4	24	31	19	16
5	21	17	25	17
6	17	8		
7	31	22	13	30
8	31	22	28	14
9	43	19	22	41
10†				
11	83	82		
12	102	94		
13	10	6		
14	28	14	12	20
15	27	36	35	40
16	52	38	37	30
17	19	9	15	8
18	48	33	30	35
19	23	21	19	26
20	78	76		
21	18	15	13	18
22	14	16	16	11
23	15	17	8	15
24	37+	37+	28+	28+
25	25	22	16	11
26	62	63		
27	37	30		
28	46	48		
29	61	69		
30	7	15		
31	30	35		
32	44	40	18	27
33	24	16	14	22
34	40	49	32	38
35	38	38	43	31
36	78	79		
37	30	22	20	29
38	58	35	30	29
39	34	32	39	39
40	26	31	24	34
41	39	33	23	27
42	78+	78+		
43	20	18	16	10
44	44+	44+	40+	40+
45	23+	23+	11+	11+
46	23+	23+	25+	25+
47	38+	38+	35+	35+
48	24+	24+	21+	21+
49	75+	75+		
50	19	19		
51	10+	10+		

TABLE III—Continued.

Culture Number.	Wild Type, Females.	Wild Type, Males.	Scarlet, Females.	Scarlet, Males.
52	46+	46+		
53	37+	37+	27+	27+
54	12	10	8	7
55	25	19	27	15
56	6	5	3	8
57	16	13	13	16
58	67	55		
59	17	17	17	22
60	18	20	25	21
61	23	18	16	18
62	8	4	3	8
63	33	33		
64	12	13		
65	5	2	2	
66	4	3	2	3
67	7	5	8	5
68	19	13		
69	89	90		
70	56	56		
71	73	65		
72	18+	26+	18+	26+
73	42	28	28	15
74	23	31	19	21
75	24	22	17	25
76	63	63		
77	27	33	40	25
78	29	25	27	15
79	49	57		
80	29	34	23	35
81	43	39	44	35
82	20	23	24	15

Total: 27 homozygous and 55 heterozygous.
†Heterozygous.

TABLE IV.

P_1 Scarlet Females by Wild Males. Results of Crossing Wild Type F_1 Males to Scarlet Females.

Culture Number.	Wild Type, Females.	Wild Type, Males.	Scarlet, Females.	Scarlet, Males.
1	2	4	2	4
2	13	4	9	4
3	17	3	12	3
4	24	25	10	6
5	14	23	17	14
6	52	41	30	50
7	64	64		
8	52	40	18	16
9	31	36	34	29
10	47	34	39	55
11	20	27	25	20
12	56	40	53	60
13	28	34	27	26
14	22	28	18	11
15	39	58	61	51
16	63	39	100	63
17	30	25	33	34
18	40	53	19	21
19	28	30	28	22

TABLE IV—Continued.

Culture Number.	Wild Type, Females.	Wild Type, Males.	Scarlet, Females.	Scarlet, Males.
20	86	92	....	....
21	136	149	....	....
22	24	42	31	22
23	94	105		
24	24	37	....	....
25	20	19	20	21
26	23	31	19	24
27	24	29	32	40
28	36	31	40	43
29	85	123	43	46
30	46	34	41	45
31	43	38	33	34
32	54	40	39	55
33	55	71	28	39
34	77+	77+	....	....
35	20	15	16	21
36	45	45	41	47
37	63	23	23	26
38	55	14	20	24
39	47	57	59	37
40	134	107	....	....
41	27	32	21	26
42	52+	52+	55	47
43	102	95	....	....
44	20	22	35	26
45	120	91	....	....
46	22	19	21	22
47	120+	120+	....	....
48	26	22	19	24
49	93	96	....	....
50	43	37	32	32
51	62	52	....	....
52†	....	....	....	....
53	83	71	....	....
54	53	36	....	....
55	55	55	41	43
56	24	29	22	21
57	52+	52+	35+	35+
58	46+	46+	50+	50+
59	42	43	25	22
60	41	44	30	51
61	38+	38+	26+	26+
62	6	7	....	....
63	15	7	9	7
64	7	19	2	14
65	9	8	8	13
66	29	30	13	14
67	21	24	23	11
68	23	12	10	5
69	39	11	....	....
70†	....	....	....	....
71	26	25	20	9
72	27	29	16	14
73	40	23	....	....
74	20	15	13	10
75	9	6	5	5
76	5	7	8	14
77	18	23	....	....

Total: 18 proved homozygous and 59 heterozygous.
†Noted as heterozygous, but no count made.

TABLE V.

P₁ Scarlet Male by Wild Female. Result of Crossing Wild Type F_2 Male to Scarlet Female.

Culture Number.	Wild Type, Females.	Wild Type, Males.	Scarlet, Females.	Scarlet, Males.
1	50	52	....	....
2	61	49	44	49
3	74	63	....	....
4	5	10	6	5
5	27	10	20	12
6	26	28	....	....
7	86	65	....	....
8	93	83	....	....
9	21	15	....	....
10	34	30	40	43
11	19	14	16	15
12	11	10	13	12
13	45	53	33	40
14	42	48	54	54
15	46	49	37	41
16	29	21	....	....
17	14	15	....	....
18	28+	28+	....	....
19	51	36	34	32
20	61	47	....	....
21	2	9	12	11
22	17	19	....	....
23	17	11	....	....
24	87	88	....	....
25	22	28	20	25
26	16	10	10	11
27	37	27	31	28
28	45	36	....	....
29	31	38	31	27
30	38	26	26	31
31	20	16	19	21
32	78	70	....	....
33	42	51	....	....
34	34	46	30	38
35	84	72	....	....
36†	....	....	....	....
37	20	23	13	22
38	7	8	65+	65+
39	46	68	38	30
40	70	74	....	....
41	31	35	32	41
42	38	23	21	12
43	10	6	5	5
44	32	41	17	28
45	3	4	6	4
46	10	12	18	6
47	30	7	19	10
48	23	20	22	18
49	7	3	6	3
50	3	2	8	4
51	60	66	....	....
52	84+	84+	....	....
53	24	21	....	....
54	27	25	28	20
55	21	20	21	19
56	11	12	....	....
57	14	11	10	9
58	5	1	2	5
59	14	5	6	4
60	25	34	....	....
61	15+	15+	16+	16+
62	10	8	....	....
63	15	13	....	....
64	5	2	2	3

Total: 25 homozygous and 39 heterozygous.

†Noted as heterozygous, but no accurate count made.

TABLE VI.

P_1 Scarlet Male by Wild Female. Results of Crossing Wild Type F_1 Female to Scarlet Male.

Culture Number.	Wild Type, Females.	Wild Type, Males.	Scarlet, Females.	Scarlet, Males.
1	89	89	.....	.....
2	49	48	23	36
3	51	50	.....	.....
4	111+	111+	.....	.....
5	25	20	15	14
6	45	40	62	50
7	88	75	.....	.....
8	10	17	.....	.....
9	31	31	17	26
10	71	79	.....	.....
11	49	46	.....	.....
12	54	56	.....	.....
13	19	29	21	24
14	71	75	25	17
15	12	14	.....	.....
16	50	41	.....	.....
17	17	22	27	19
18	53	50	.....	.....
19	28	34	37	29
20	50	39	46	41
21	7	13	4	6
22	19	19	14	21
23	13	23	.....	.....
24	29	30	23	18
25	35	36	.....	.....
26	56	52	20	31
27	68	40	.....	.....
28†	.....	.....	.....	.....
29	30	31	21	26
30	26	24	21	23

Total: 14 homozygous and 16 heterozygous.

†Noted as heterozygous, but no accurate count made.

A Seasonal Study of the Kidney of the Five-Spined Stickleback, Encalia Inconstans Cayuga Jordan.

Walter N. Hess—DePauw University.

During the greater part of the year the male kidney is an excretory organ. At the breeding season, however, the kidney tubules, for about one-third of their extent, as well as the urinary ducts, the bladder and the common urinary duct become modified for the purpose of producing slime. This secretion, which is used by the fish in constructing its nest, is produced entirely by the male kidneys and only at the breeding season.

In the process of slime secretion, the behavior of the nuclei is such that they evidently pour into the cell bodies certain products, in the form of secretion granules, which function in breaking down the granular cytoplasm of the cells, and thus form the secretion. These secretion granules appear to be produced from certain products of the karyoplasm, as this substance gradually diminishes in amount during this process. Since the nuclei become irregular and flattened, it is possible, but not probable, that the nucleolus functions in this process.

Only one kind of secretion is produced for constructing the nest. This material is not silk, nor is it composed of fine fibrils, but appears as a fine granular slime-like substance. It is sometimes exuded in ribbon-like masses, but it probably functions more as an adhesive substance, than as a string, in binding the materials of the nest together.

At the end of the breeding season the cytoplasmic granules are regenerated. They begin to appear on all sides of the nucleus at the time that the nucleus begins to enlarge and become spherical. Since they form about the nucleus and wander into the other parts of the cell it would seem that the nucleus must be the active agent in their formation.

During the resting or winter stage the cells which form the slime during the spring appear much like the cells near the glomeruli which secrete urine, except that their nuclei are much smaller and they contain only one nucleolus. At this season the nuclei of the urinary secreting cells are very large, often occupying at least half of the cell contents.

This investigation justifies the conclusion that the whole kidney is not transformed periodically into a silk or slime producing gland, as is maintained by certain authors, but that the process of slime secretion is due to the activity of the epithelial cells of various ducts and tubes of the system not engaged in the excretory function. It is comparable to the secretion of slime by the genital ducts of Amphibia during the breeding season.

THE ERDMANN NEW CULTURE MEDIUM FOR PROTOZOA.

C. A. BEHRENS and H. C. TRAVELBEE—Purdue University.

It is a well-known fact that the first culture *in vitro* of a pathogenic trypanosome (Tryponosoma Brucei) was obtained by Novy and MacNeal[1] in 1903. The medium used was a meat extract agar plus two parts of defibrinated rabbit's blood. Of fifty animals tested only 4, or 8% positive cultures resulted. In 1905 Smedley[2], using a similar medium, found that three out of ten attempts, or 30%, were successful.

Because of the inconsistent results we deemed it advisable to attempt an improvement of the medium. The first attempts along these lines were in 1909[3]. The media with their per cent. of positive growths are as follows:

1	Novy MacNeal blood agar	25%
1A	Novy MacNeal blood	0%
2	Bean and pea extract blood agar	53%
2A	Bean and pea extract blood	0%
3	Nicolle blood agar	48%
3A	Nicolle blood	0%
4	Dialyzed meat extract blood agar	80%
4A	Dialyzed meat extract blood	0%
5	Dialyzed meat extract dilute serum agar	100%
5A	Dialyzed meat extract dilute serum	0%
6	Dialyzed meat extract inactivated serum agar	100%
6A	Dialyzed meat extract inactivated serum	0%
7	Dialyzed meat extract dilute red blood cells agar	38%
7A	Dialyzed meat extract dilute red blood cells	0%
8	Dialyzed meat extract Ascitic fluid agar	0%
8A	Dialyzed meat extract Ascitic fluid	0%
9	Veal extract blood minus white blood cells agar	100%
9A	Veal extract blood minus white blood cells	0%

[1] Jour. Amer. Med. Assn., 1903, 41, p. 1266; Jour. Infect. Dis., 1904, 1, p. 1.
[2] Jour. Hyg., 1905, 5, p. 38.
[3] Jour. Infec. Dis., 1914, 15, 1, p. 4.

The above table indicates that successful cultures ranging from 25 to 100 per cent. are obtained when the solid type of medium is employed and that in every case where the liquid medium is used negative results occurred. In the successful cultures growth always resulted in the water of condensation after a period of incubation from one to four weeks at a temperature ranging from 25° to 28° C.

We therefore naturally were very much interested when in 1914 Rh. Erdmann[4] announced a new liquid culture medium for Trypanosoma Brucei. Erdmann states that by using the plasma of the host as the medium she grew Trypanosoma Brucei in hanging-drop cultures and kept them in normal condition for an indefinite period. The technique employed in brief was as follows: The plasma was obtained by the method of Harrison[5], Burrows[6], and Walton[7]. "The blood from the infected rat was taken and put into a small drop of plasma on a cover-glass and then this was further diluted with plasma in order to reduce the number of blood corpuscles in the hanging-drop which was taken from this." The cover glass with hanging-drop was either placed on a depression or regular slide and sealed. Precautions to secure aseptic conditions were taken.

We attempted to follow the technique thus outlined as nearly as possible. These cultures showed no signs of bacterial contamination at the end of forty-five days. In only a few instances were actively motile survivals in evidence for more than five days when kept at 10°C. In preparations incubated at 20°C, or above no survivals were observed after forty-eight hours.

In the course of an extensive series of attempts using heterologous and homologous sera under various conditions we found it impossible at any time to obtain a second generation by the Erdmann method. The homologous sera used were rat and guinea pig. The heterologous sera were human, horse, beef, sheep, pig, rabbit and chicken. These sera were used in a dilute one to one, inactivated, and normal form and the preparations were incubated at temperatures of 10, 15, 20, 25, 28, 30, 35, 37½, and 40°C. Ascitic fluid was also used without success.

It is true that trypanosomes will multiply and remain actively

[4] Soc. Exp. Biol. and Med., 1914, XII, p. 57.
[5] Proc. Soc. Exp. Biol. and Med., 1907, IV, p. 40; Jour. Exp. Zool., 1910, IX, p. 787.
[6] Jour. Amer. Med. Assn., 1910, LV; Jour. Exp. Zool., 1911, X, p. 63.
[7] Proc. R. S. L., Ser. B., 87, p. 452.

motile when first placed in a medium such as described by Erdmann. We have especially noticed this in connection with our work with solid media. Good survival forms of other pathogenic trypanosomes as those causing human sleeping sickness, dourine, and mal de caderas were observed as late as the twenty-eighth day, but in no case did these forms result in positive growth or second generation when transplanted to similar medium under similar conditions.

In summing up our work we can positively say that at no time, under no conditions were we able to obtain a positive culture using the Erdmann cultural medium. As a matter of fact the easily cultivated trypanosome of Lewis would not develop successfully on this medium.

DISPOSITION AND INTELLIGENCE OF THE CHIMPANZEE.

W. HENRY SHEAK—Philadelphia, Pa.

I shall not, in this brief paper, attempt to prove aught of the disposition and intelligence of *Anthropopithecus troglodytes* by force of argument. I shall merely set forth a few of my own personal observations. You may draw your own conclusions.

The chimpanzee is a native of tropical Africa, ranging from about twelve degrees north of the equator to ten degrees south of this line, and from the Atlantic Ocean on the west, to the Blue Nile on the east. But these interesting animals seem to be much more abundant in the western part of their range than in the eastern; at least, most of the specimens we get in captivity come from near the Atlantic. The chimpanzee is not nearly so large as the gorilla, and possibly not quite so large as the orang-utan, but there is not much difference in size between the chimpanzee and the orang. The adult males reach a height of about four feet five inches and a weight of from one hundred and forty to one hundred and sixty pounds. The females are not quite so large. The color is black, both the hair and skin being black. In some specimens, however, the face is quite light in color, and in others there may be found considerable ashy-gray hair among the black.

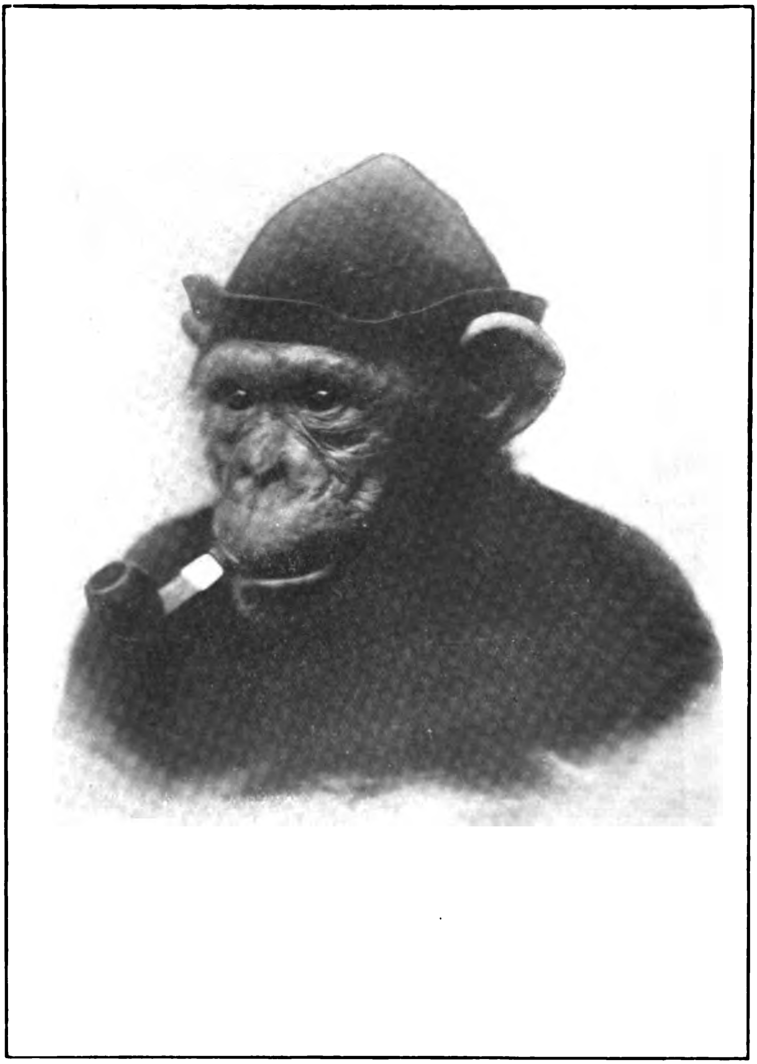
The chimpanzee is the most friendly and docile of the great apes, differing in this way from his near relative, the gorilla, which is savage and morose, refusing to make friends with man. I have seen a young chimpanzee fresh from the jungles, on being taken from the shipping box in which he came to America, throw his arms about a man's neck he had never seen ten minutes before, and hug him affectionately. To me, one of the most interesting things about these great apes is that they know how to express affection and gratitude by hugging and kissing without being taught. A few years ago I had a big chimpanzee called Mike, who insisted on kissing me, and kissing me on the lips, whenever I came near him. This was not the most delightful of experiences, because Mike's lips were not always clean. Joe, a smaller specimen,

Skeleton of a Chimpanzee, showing close resemblance in structure to man.

very intelligent and affectionate, and my special pet, would often cuddle up close to me, and if I did not voluntarily put my arm about him, he would take hold of my arm and fold it about his shoulders or waist.

When Joe was only a baby, he fell into the habit of pulling my hand to his mouth and biting my fingers, while I was talking to the people about him. He was only playing and did not intend to hurt me; but often, in his efforts to get my hand to his face and in snapping at my fingers, he would bite harder than he intended. Then, too, it was tiresome to have him pulling on me when I was trying to talk. One morning I got tired of his pulling and biting. I was carrying a small stick and gave him a light tap on the bare arm. He stopped instantly, lifted his pretty brown eyes to mine with an expression of pained surprise and incredulity upon his face, as if he could not believe I would hit him. After looking at me thus intently for fully half a minute, he put up his hands, folded his little black arms about my neck, and hugged me, three times, before he would let me go. This display of wounded feeling and tender affection almost brought tears to my eyes.

The chimpanzee is also affectionate towards members of his own species and towards other animals, especially his nearest relatives, the simians. Recently we had three chimpanzees in our collection, Mike and Joe, already mentioned, and Jerry, a baby about thirteen months old. Joe and Mike were both devoted to the baby and were always ready to fight for him. Mike usually mothered the little fellow, keeping him under his especial care, and was jealous of Joe. One morning Joe appropriated the baby and sat on the floor holding him on his lap, much the same way that a very small boy holds his very big baby brother. Mike wanted the baby and insisted upon having him. The two almost came to blows (or bites) over the youngster. Mike was itching for a fight but knew that sure and condign punishment awaited him if he hurt his smaller companion. First, he took a handkerchief and tried to strike Joe with it, much in the spirit of the young man who wanted to fight, but was afraid, and exclaimed, "I'm so mad at you I could chew paper." Then he doubled up his fist and commenced a fusillade of very light taps, delivered in very rapid succession about the neck and shoulders of his rival, just to show him what he would like to do, if he dared.



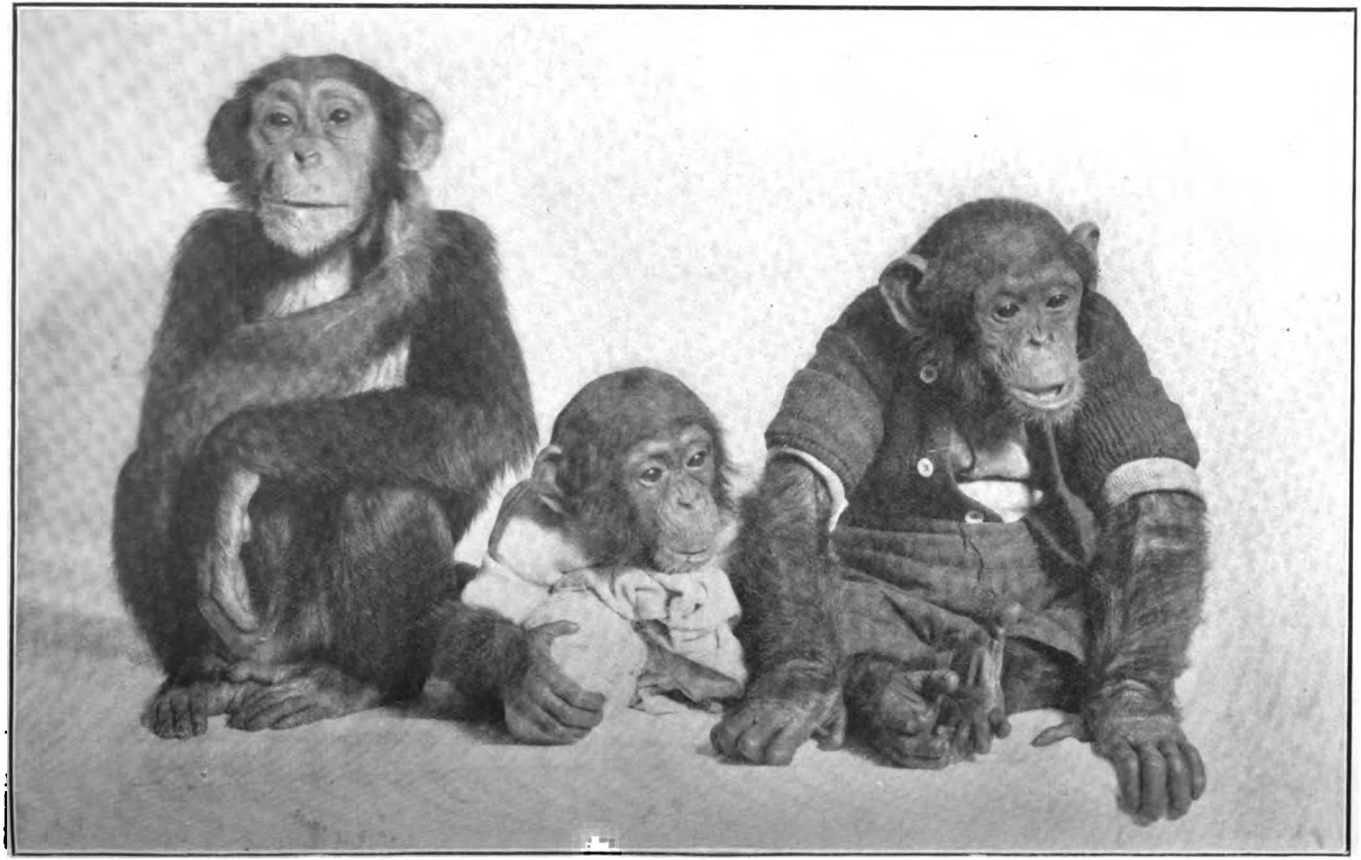
Fresh from the Old Sod—A big Chimpanzee.

One day baby Jerry was on top of a cage, when he caught hold of a large wooden ring suspended from a rope, and swung off. He was now quite a distance from the floor, and was afraid to drop. He could not swing back to the cage. Mike saw his dilemma, got on top of the cage, reached out, caught the baby, folded him in his arms, and carried him in safety to the floor. The keepers had always to be on their guard when handling Jerry, for fear Mike would mistake their intentions and attack. One evening, in Rochester, N. Y., a little girl came behind the guardrail, attracted by the cunning antics of the baby, when Mike hit her a blow in the face that brought the blood.

When Jerry died, Mike, who had been sleeping with him, went into the box and felt all over the body. When the body was taken in to the basement, Mike insisted on following, and had to be driven back with a shovel. He went to bed, but when he found out Jerry was not there, he got up and came out again. He then sat about for an hour or more, grieving and crying in the strangely human-like voice of his species. For several days he was listless and spiritless.

After years of experience in studying these animals and living with them, I have come to the careful and deliberate conclusion that, up to about four years of age, the chimpanzee babe is not only more precocious, but more intelligent than a human child of the same age. But after about four years the chimpanzee babe begins to fall behind and the human child to go ahead.

Joe learned to brush his hair with a hairbrush, to dust his clothes with a whiskbroom, to wipe his nose with a handkerchief, to eat out of a cup with a spoon as well as any human child, to bore holes with a brace and bit, to use a handsaw quite dexterously, to take screws out of the guardrail with a screwdriver, to drive nails with the hammer and pull them out again with the claw of the hammer, to play on a toy piano, and to play on a mouthharp. This last is a very difficult trick to teach an animal. You can not tell him to expel the air from his lungs and you can not show him how to do it. He must pick it up himself. I have known two or three elephants to learn this trick, but, aside from these, Joe was the only other I ever knew to accomplish the feat. All these tricks he learned with little or no teaching. He was a very close



Mike. Jerry. Joe.

Three of the Chimpanzees frequently mentioned in the context.

observer, and whatever he saw his human friends do, he would try himself, until he had acquired a long string of accomplishments.

In Chicago an employe of the menagerie brought from a Chinese restaurant a menu card printed in red ink. Joe seemed much interested in this and carefully kept it for a week or ten days. With considerable deliberation he would spread it out on the floor, then follow the lines slowly with his finger, as if reading. I have observed that most chimpanzees are right-handed, but Joe was left-handed. He always used a hammer or saw in his left hand, and in studying this menu card he would follow the lines with the index finger of his left hand.

Like human children, chimpanzees are fond of candy. But sweets are forbidden the menageries, owing to the fact that the chimpanzee stomach will bear but little sugar. In spite of the printed placards, however, well-meaning but unwise visitors would often throw them candy. One afternoon Joe was enjoying to the full a morsel of the proscribed dainty, when he saw his master approaching. He cunningly ducked his head under a blanket so the cruel tyrant, as he doubtless considered his humanu persecutor, could not see what he was eating. His cleverness was awarded by telling him to eat the candy. Joe dearly loved to tease a small Mexican hairless dog, called Harry, which usually slept on the stage near the chimpanzee cage. He would reach through the bars, give the dog a punch, pinch him, or pull his tail, then jerk his hand before Harry could nip him. In this way he kept the dog irritated much of the time, and he was always ready to bite him. One morning the manager came in with some oranges, a fruit of which the chimpanzee is very fond. To see how Joe would solve the problem, he placed one of the oranges directly under the dog's nose.

Joe was puzzled at first, but he soon had an idea. He brought the hammer from the other end of the cage, and with this in his right hand began punching at Harry. The dog was ready for a fight, as usual, and began biting at the hammer handle. In this way he gradually enticed him away from the orange, then he reached out with his left hand and took the fruit.

While exhibiting our animals in Kansas City, we kept the chimpanzees in a big cage, almost as large as an ordinary bedroom. To the top of the cage we had several ropes attached by means of bolts, with a

ring for a head. The chimpanzees would swing on these ropes, chasing each other from end to end of the cage. We found that the more exercise they took, the longer they would live in captivity. One day one of the bolts came loose and fell to the floor. The manager got into the cage, picked up the bolt and handing it to Joe, told him to put it up there in place, pointing to the hole, and hold it until he could make it fast. Joe took the bolt, climbed to the top of the cage, put it into its proper hole and held it there until the manager got on top and fastened it. The head keeper was standing near, and exclaimed, "By George, that's going some." His words expressed the thought of all us. It was the strongest manifestation of intelligence I had ever seen from an animal.

One Christmas morning a gentleman with a Great Dane came into the room. Mike and Joe were much excited and not a little afraid of the dog. Joe climbed over the senior partner's back. Mike got a piece of board into which Joe had been driving nails, and made desperate attempts to throw it. He would swing his arm back and forth, but did not seem to understand just when to let go, and the board was just as likely to go back over his shoulder as toward the dog. But now and then he came very near the dog and hit him a telling blow. Mike kept practicing at throwing till he became expert. He got into the infamous habit of throwing the hammer out among the people in front of the stage, and we had to keep it out of his reach. The wife of the manager came out of the kitchen with a half head of cabbage and cast it over the bars onto the stage, there being no top on to the chimpanzee cage at that time. Mike picked up the cabbage and tossed it back to her with just as much dexterity and precision as she had used.

We once had a very intelligent chimpanzee called Sallie. A negro connected with the menagerie had a needle and thread with which he mended his clothes. Sallie watched the operation very intently. A little later she was noticed with a string trying to find an eye in a nail. She was given a small darning needle, and a heavy cotton thread, and at once threaded the needle, just as she had seen the negro do. After that she could not be deceived. When given a nail or piece of wire, she would look for an eye and, if there was none, she would throw away the counterfeit. She would begin by wetting the end of the thread in her mouth, would place the eye of her needle in line with her eye, insert the thread

from behind forward, then pull the thread the remainder of the way with her lips. She often tried to tie a knot, too; but in this she was never successful. She always tried to make the knot in the thread up next to the needle. After a number of successful attempts at this, she would go to work on her dress, and sew, and sew, and sew, pulling the thread clear at every stitch. Sometimes she would amuse herself in this way for half an hour.

I often wondered if these very intelligent animals really understood the meaning of words, or whether they only comprehended a sentence or phrase as a whole or got the idea from my gestures or the order of the performance. One morning I saw an opportunity to test the matter. We had a little hat which I would hand to Sallie and tell her put on her "five dollar" hat. This she would generally do very neatly and skillfully, but sometimes in the morning, when she had just gotten out of bed, or at night, when she was tired and sleepy, she would respond very indifferently, either getting the hat on one side or missing her head altogether. I always had her put on her hat immediately after shaking hands at the beginning of the lecture. On the morning in question, the hat had fallen to the stage floor near her feet. Shortly after the lecture commenced, as I was finishing the talk, I said to her without changing my tone or looking toward the hat, "Sallie put on your five dollar hat." Without the slightest hesitation, she reached down, picked up the hat, and put it on her head.

Joe learned the order of the performance, and when I got through describing his hand to the audience, he would proffer his foot. He seemed, too, to understand the meaning of "posterior limb," for, although I might change the order of the lecture, the instant I sad "posterior limb," he would put up his foot.

One afternoon, in Detroit, some one had given Mike something to eat in a common earthenware bowl. When I came up, he had almost emptied the vessel. I knew he would throw it to the floor and break it, so I stepped behind the guardrail and said, "Mike, hand me that bowl." Immediately he set down the bowl and put out his hand. I saw at once that I, not he, had blundered. The word "bowl" was new to him, he had never heard it before; but as I had told him to hand me the bowl, he set down the vessel and offered me his hand. So I changed the form of the

command, "Give me that cup." He was perfectly familiar with the word "cup", as he kept one on the platform and, when he was thirsty, gave it to the keeper to fetch him a drink of water. Without hesitation he picked up the bowl and gave it to me, doubtless considering it merely a cup of larger size.

One day, when our Joe was a little fellow, he and one of the keepers got into an argument. The keeper wanted Joe to sit on his chair, but he refused to do so. Bad temper and angry passions were prevailing on both sides. The keeper had a whip and was threatening to strike. Joe was showing his teeth and threatening to bite. I stepped behind the guardrail and sent the keeper on an errand out of the room. I spoke a few soothing words to Joe. He stopped screaming and got up on his chair. In a moment he had forgotten his trouble. A bystander wanted to know the secret of my influence over the animal. It was kindness and love.

The Uredinales of Delaware.[1]

H. S. Jackson—Purdue University.

The following account of the Uredinales of Delaware is the result of a study of the rust flora of that State begun in 1906, during the time when the writer was connected with the Delaware College and Experiment Station. A preliminary manuscript was prepared at that time and has since been revised and amplified at various times and finally rewritten in the present form in the winter of 1916-1917. A few changes and additions have since been made to bring the notes up to date.

The records include all the material in the Herbarium of the Delaware College Agricultural Experiment Station, together with the collections made by the writer during a period of three years, and most of the collections made by the late Mr. A. Commons of Wilmington, Delaware.

Mr. Commons made a very extensive collection of the Phanerogams and Fungi of the State, largely during the period from 1885 to 1895. Most of the fungi were determined by Mr. J. B. Ellis and duplicates of the specimens are now in the herbarium of the New York Botanical Garden. A manuscript list of the fungi was prepared by Mr. Commons, but never published.

The writer enjoyed the privilege of a conference with Mr. Commons in 1907 and was permitted to make a record of the rusts from his manuscript list. His collection was not available for consultation at the time, having been stored in boxes in a garret in Wilmington. Duplicates of most of the specimens, however, have been found and examined in the Ellis herbarium at the New York Botanical Garden. Only those specimens which the writer has seen are included in the present account.

A total of 129 species are recorded from the State, including the unconnected species of Aecidium and one uncertain Uredo. These are recorded on 232 different hosts. A total of about 450 collections are included, the greater number of which were made by the writer.

In recording the collections, the nearest postoffice is given, together

[1] Contribution from the Botanical Department of the Purdue University Agricultural Experiment Station.

with the date and name of the collector if made by another person than the writer. The numbers in parentheses following the date are the writer's accession numbers. Collections made at Seaford, July 9, 1907, at Clayton, July 24, 1907, and at Lewes, August 14, 1907, were made in company with Dr. M. T. Cook. In the case of collections made by Mr. Commons the numbers given are those of his manuscript list.

An attempt has been made to include in the notes a review of all the American culture work, together with some reference to similar work conducted by European workers.

A number of field observations which were made at the time of collecting the specimens have since been used by Dr. J. C. Arthur as the basis for successful culture work and have been recorded elsewhere. A considerable number of collections of material for culture work were supplied him, a number of special trips having been made primarily for this purpose, the expenses for which he provided from the funds of the Purdue University Agricultural Experiment Station. Many of the specimens collected, especially those on grasses and sedges, were identified by Dr. Arthur or his associates in rust work. Many others, originally determined by the writer, were sent him from Delaware for confirmation. Throughout the period of time when the collections were being made, a continuous correspondence was carried on with Dr. Arthur which proved very stimulating and the writer is under special obligations to him for this assistance. Acknowledgment is also gratefully made to any others who have in any way aided in the work.

COLEOSPORIACEAE

1. Coleosporium carneum (Bosc.) comb. nov.

    Tubercularia carnea Bosc. Ges. Nat. Freunde Berlin Mag. 5:88. 1811.

    Coleosporium Vernoniae B. & C. Grevillea 3:57. 1874.

    Peridermium carneum Seymour & Earle, Econ. Fungi 550. 1899.

    On Carduaceae: II, III.

    Vernonia noveboracensis (L.) Willd., Lewes, Aug. 14, 1907, (1680); Collins Beach, Oct. 1, 1907, (1912); Newark, Oct. 25, 1907 (1978.)

Arthur (Mycol. 4:29. 1912), in 1910 proved that *Peridermium carneum* is genetically connected with *Coleosporium Vernoniae*. Success-

ful infection, resulting in the formation of uredinia and telia was obtained by sowing aeciospores from *Pinus taeda* on *Vernonia crinita*, from Florida. These results were confirmed in 1911 by the same author (Mycol. 4:57. 1912), who obtained successful infection on *V. gigantea*, using aecial material from Mississippi; and again in 1913 and 1914 (Mycol. 7:80, 84. 1915), when infection of *V. fasciculata* was obtained from aecial material on *P. taeda* and *P. palustris* collected in Florida.

The type of *Tubercularia carnea* has not been seen, and presumably is not in existence. It seems desirable, if this name is to be retained at all, to restrict its use to the Vernonia combination or, in case it should later be found desirable to unite this species with *C. Elephantopodis*, for the combined species. Hedgcock & Long (Phytopath. 7:66-67. 1917) record culture work indicating that the two species may be identical. See also Phytopathology 8:321, 325. 1918.

2. COLEOSPORIUM DELICATULUM (Arth. & Kern) Hedgcock & Long, Phytopath. 3:250. 1913.

Peridermium delicatulum Arth. & Kern, Bull. Torrey Club 33:412. 1906.

ON CARDUACEAE: II, III.

Euthamia graminifolia (L.) Nutt., Newark, September 1888, F. D. Chester; Clayton, July 24, 1907, (1706); Felton, Sept. 5, 1907, (1746); Selbyville, Oct. 4, 1907, (1990).

This species until recently has been included with *C. Solidaginis*. The first suggestion leading to a true understanding of its relationship was made by Clinton in 1912 (Conn. Agr. Exp. Station Report 1912:352. 1913) who observed *P. delicatulum* on *Pinus rigida* in Connecticut associated in the field with Coleosporium on *Solidago graminifolia*. He pointed out a morphological correlation between the spore wall markings of the aeciospores and the urediniospores of the two forms but no cultures were attempted.

Hedgcock and Long in 1913 (l. c.) showed by infection experiments that this form is distinct and is connected genetically with *Peridermium delicatulum*. Uredinia developed on Euthamia when inoculated with aeciospores of *P. delicatulum* on *Pinus rigida*.

For a record of additional culture work see Phytopathology 8:321. 1918.

3. Coleosporium Elephantopodis (Schw.) Thüm. Myc. Univ. 953. 1878.
Uredo Elephantopodis Schw. Schr. Nat. Ges. Leipzig 1:70. 1822.
On Carduaceae: II, III.
Elephantopus caroliniana Willd., Greenbank, Aug. 24, 1886, A. Commons (318); Selbyville, Oct. 4, 1907, (1753).

Hedgcock & Long (Phytopath. 7:66-67. 1917) record culture work which indicates that this species is identical with *C. Vernoniae*. Further information regarding this situation is to be found in Phytopathology 8:321, 325. 1918.

4. Coleosporium Ipomoeae (Schw.) Burr. Bull. Ill. Lab. Nat. Hist. 2:217. 1885.
Uredo Ipomoeae Schw. Schr. Nat. Ges. Leipzig 1:70. 1822. *Peridermium Ipomoeae* Hedgc. & Hunt, Mycologia 9:239. 1917.
On Convolvulaceae: II, III.
Ipomoea hederacea (L.) Jacq., Lewes, Aug. 14, 1907, (1683); Selbyville, Oct. 4, 1907, (1982).
Ipomoea pandurata (L.) Meyer,—Faulkland, Sept. 18, 1885, A. Commons (219).
Ipomoea purpurea (L.) Roth.—Lewes, Aug. 14, 1907 (1694). Newark, Sept. 15, 1905 (1539).

Hedgcock & Hunt (Phytopath. 7:67. 1917) have shown that a previously undescribed foliicolous species of Peridermium, to which they give the name *P. Ipomoeae*, is the aecial stage of this species.

5. Coleosporium Pini Gall. Jour. Myc. 7:44. 1891.
Gallowaya Pini Arth. Result. Sci. Congr. Bot. Vienne 336. 1906.
On Pinaceae: III.
Pinus virginiana Mill.—Seaford, June 4, 1908, (2095).

This species represents the type of the genus Gallowaya Arth. which up to the present time remains monotypic. It is in its life history a short cycle Coleosporium bearing the same relation to that genus that Necium Arth. does to Melampsora Cast. and Chrysomyxa Ung. to Melampsoropsis (Schröt.) Arth., etc., as proposed in the revised classification of Arthur (l. c.).

Galloway (Bot. Gaz. 22:433-452. 1896) has made a very thorough investigation of the life history, pathological histology and the effect of this fungus on this host. A large series of inoculations were carried out

proving conclusively that the fungus is autoecious and that telia only are included in the life cycle.

6. Coleosporium Solidaginis (Schw.) Thüm. Bull. Torrey Club 6:216. 1878.

Uredo Solidaginis Schw. Schr. Nat. Ges. Leipzig 1:70. 1822.

Periderminum acicolum Und. & Earle, Bull. Torrey Club 23:400. 1896.

Peridermium montanum Arthur & Kern, Bull. Torrey Club 33:413. 1906.

On Pinaceae: I.

Pinus rigida Mill.—Seaford, June 5, 1908, (2066, 2094); Harrington, June 5, 1908 (2257).

On Carduaceae: II, III.

Solidago canadensis L.—Newark, September, 1888, F. D. Chester; Seaford, July 9, 1907, (1644); Clayton, July 24, 1907, (1704); Lewes, Aug. 14, 1907, (1697, 1701).

Solidago rugosa Mill., Lewes, Aug. 14, 1907, (1698).

Aster paniculatus Lam. Newark, October, 1907, (2265, 2248).

The life history of this species was first worked out by Clinton (Science N. S. 25:289. 1907. Ann. Rep. Conn. Exp. Sta. 1906:320. 1907; 1907:375. 1908). He successfully infected *Solidago rugosa* with aeciospores of *Peridermium acicolum* on *Pinus rigida*. The aecial material used was collected in three localities in Connecticut and three trials were made, all of which resulted in the development of uredinia. Telia followed in two cases.

More recently Hedgcock (Phytopath. 6:65. 1916) and Wier and Hubert (Phytopath. 6:68. 1916) working independently, have shown that, in Montana, the species under discussion has for its aecial stage a Peridermium common in the west on the needles of various pines, known as *P. montanum* Arth. & Kern. Hedgcock sowed aeciospores collected on *Pinus contorta* in Montana on various hosts and obtained the development of aecia and telia on *Aster conspicuous*. Wier & Hubert also sowed aeciospores from the same host and State on a number of local hosts for Coleosporium and obtained infection resulting in aecia on *Solidago canadensis*, *S. missouriensis* and *Aster laevis geyeri*.

A review of the present knowledge with reference to this species can be found in Phytopathology 8:324. 1918.

UREDINACEAE.

7. CRONARTIUM CEREBRUM (Peck) Hedgcock & Long, Jour. Agr. Res. 2:247. 1914.

Peridermium cerebrum Pk. Bull. Buff. Soc. Nat. Sci. 1:68. 1873.

Aecidium giganteum Mahr. Wald. Nordam. 120. 1890.

Cronartium Quercuum Miyabe; Shirai, Bot. Mag. Tokyo 13:74. 1899.

Peridermium fusiforme Arth & Kern, Bull. Torrey Club 33:421. 1906.

ON PINACEAE: I.

Pinus virginiana Mills., Seaford, April 1908, (2250).

ON FAGACEAE: II, III.

Quercus coccinea Wang., Seaford, July 9, 1907, (1645).

Quercus digitata (Marsh.) Sudw., Seaford, July 9, 1907, (1641, 1642) (Barth. Fungi Columb. 2720); Lewes, Aug. 14, 1907, (2249).

Quercus marylandica Moench., Seaford, July 9, 1907, (1646, 1647, 1652), (Barth. Fungi Columb. 2719); Lewes, Aug. 14, 1907.

Quercus nigra L., Seaford, July 9, 1907, (1643).

The first record of culture work with this species was made by Shirai (Bot. Mag. 13:74. 1899). He successfully inoculated *Quercus serrata*, *Q. variabilis* and *Q. glandulosa* in Japan, with aeciospores of *Peridermium giganteum* (Mahr.) Tubeuf from native Pinus sp.

Shear (Jour. Myc. 12:89. 1906) was the first in America to report successful inoculation indicating the connection of *Peridermium cerebrum* with the American Cronartium on Quercus sp. He conducted out-of-door inoculation experiments in the vicinity of Washington, D. C., using aeciospores of *Peridermium cerebrum* on *Pinus virginiana* to infect *Q. coccinea*. The experiments resulted in the formation of uredinia followed by telia. He also records convincing field observations confirming the above mentioned culture work.

Arthur in the same year (Jour. Myc. 13:194. 1907) confirmed Shear's results under greenhouse control by obtaining successful infection on *Q. velutina* which resulted in the formation of uredinia and telia following sowings with aecial material furnished by Dr. Shear, on *Pinus virginiana*. These results were confirmed by the same author in 1910 (Mycol. 4:26. 1912) when infection was obtained on *Q. rubra* using aecia on *P. virginiana* from the same locality.

Hedgcock in 1908 (Phytopath, 1:131. 1911) infected *Q. lobata, Q. rubra* and *Q. densifolia echinoides* by sowing with aeciospores from *Pinus virginiana* and *P. echinata*, resulting in the formation of uredinia and telia on all hosts. He also records further inoculation experiments in 1909 and 1910 in which 14 additional species of Quercus were successfully infected as was also *Castanopsis chrysophylla*. Typical galls were produced on five species of pines by introducing teliospores from the oak into wounds on the limbs. Many cross inoculations are recorded between species of Quercus in which uredospores were used.

Later Hedgcock & Long (Jour. Agr. Res. 2:247. 1914) record further inoculation work extending as well as confirming the above results and also show by carefully conducted inoculation experiments that *Peridermium fusiforme* is a synonym of the species under discussion.

Arthur in 1913 (Mycologia 7:79. 1915) confirms Hedgcock and Long's findings with reference to *Peridermium fusiforme*, obtaining successful infection of *Q. rubra* and *Q. Phellos*, following sowings with aeciospores from typical galls of this species on *Pinus taeda* from Alabama.

A more recent view with reference to the relation of *Peridermium cerebrum* and *P. fusiforme* to the Cronartium on oaks will be found in Phytopathology 8:315-316. 1918.

8. CRONARTIUM PYRIFORME (Peck) Hedgcock & Long, Alt. Stage Peridermium pyriforme 3, 1914.

   Cronartium Comandrae Peck, Bot. Gaz. 4:128. 1879.

   Peridermium pyriforme Peck, Bull. Torrey Club 6:13. 1875.

   ON SANTALACEAE: II, III.

   Comandra umbellata (L.) Nutt., Harrington, June 6, 1908, (2070).

Orton & Adams (Phytopath. 4:25. 1914) record convincing field observations made in Pennsylvania which led to the conclusion that the aecial stage of this species was the much confused *Peridermium pyriforme* Pk. No cultures were attempted.

Hedgcock and Long (l. c.) were the first to conduct cultures. They succeeded in infecting *Comandra umbellata* by sowings with aeciospores from *Pinus ponderosa*, resulting in typical uredinia.

In a later publication (Bull. U. S. Dept. Agr. 247:5. 1915) the same

authors discuss this fungus at considerable length and record in detail the results of infection experiments.

Kirkwood (Phytopath. 5:223-224. 1915) records field infection experiments conducted in 1912 in which *Comandra pallida* was infected by aeciospores from *Pinus ponderosa.* The results were inconclusive. In 1914 teliospores were inserted in incisions in the bark of young pine trees resulting in a development of mycelium in the tissues, which on histological examination resembled the condition found in trees known to be natually infected. Further field infections similar to those conducted in 1912 were carried out in 1914.

9. HYALOPSORA POLYPODII (DC.) Magn. Ber. Deuts. Bot. Ges. **19**:582. 1901.

Uredo Polypodii DC. Fl. Fr. **6**:81. 1815.

ON POLYPODIACEAE:

Felix fragilis (L.) Und., Stanton, July 4, 1894, A. Commons (2466); Mt. Cuba, July 1894, A. Commons (Distributed in Ellis & Ev. Fungi Columb. 765).

The evidence at hand at the present time leads to the conclusion that this species and other members of the genus Hyalopsora are heteroecious. Bartholomew (Bull. Torrey Club 43:195. 1916) shows that the mycelium of this species is binucleate in all its forms on the above host. No clues to the alternate host have been suggested.

10. KUEHNEOLA UREDINIS (Lk.) Arth. Result. Sci. Congr. Bot. Vienne 342. 1906.

Oidium Uredinis Lk. in Willd. Sp. Pl. **6**^{1}:123. 1824.

Chrysomyxa albida Kühn, Bot. Centr. **16**:154. 1883.

Uredo Muelleri Schröt. Krypt. Fl. Schles. **3**^{1}:375. 1887.

Coleosporium Rubi Ellis & Holw. Sacc. Syll. Fung. **7**:759. 1888.

ON ROSACEAE:

Rubus nigrobaccus Bailey, Faulkland, Sept. 15, 1885, A. Commons (175), Oct. 1, 1886, A. Commons (175a) (type of *Coleosporium* Rubi Ell. & Holw. issued in Ellis & Ev. N. Am. Fungi 1878); Newark, Sept. 5, 1905 (1629).

Rubus frondosus Bizel. Newark, Sept. 1907 (2012).

11. **Melampsora Bigelowii** Thüm. Mitth. Forstl. Vers. 2:37. 1879.
Uredo Bigelowii Arth. Result. Sci. Congr. Bot. Vienne 338. 1906.
On Salicaceae: II, III.
Salix nigra Marsh., Wilmington, Oct. 4, 1889, A. Commons (1022); Newark, Oct. 6, 1905 (1634), Sept. 10, 1907 (1729).

Arthur in 1903 (Jour. Myc. 11:60. 1905) was the first to show that this American species, like certain European forms on Salix, develops its aecial stage on Larix. He obtained the development of aecia on *Larix decidua* by using for infection, telial material on *Salix amygdaloides*, from Wisconsin. These results were confirmed in 1906 (Jour. Myc. 13:194. 1907) when similar successful infection was obtained on *L. decidua* following exposure to germinating telia on Salix sp. from Indiana. Wier and Hubert (Phytopath. 6:372. 1916) used telia on *Salix Bebbiana* from Montana to successfully infect *L. occidentalis*, and on *S. cordata mackenzieana* from Idaho to infect *L. Europea*. Pycnia and aecia developed in abundance from both infections. (See also Phytopath 7:109. 1917; 8:326. 1918.)

12. **Pucciniastrum Agrimoniae** (Schw.) Tranz. Script. Bot. Hort. Univ. Petrop. 4:301. 1895.
Caeoma Agrimoniae Schw. Trans. Am. Phil. Soc. II, 4:291. 1832.
On Rosaceae: II, III.
Agrimonia hirsuta (Mühl.) Bicknell, Newark, Sept. 19, 1905, (1547); Oct. 1907 (2235).

No culture work leading to the detection of the alternate form of the species has been conducted. The aecia, in common with other North American species of Pucciniastrum, doubtless occur on the leaves of Abies or Tsuga.

13. **Pucciniastrum minimum** (Schw.) Arth. Result. Sci. Congr. Bot. Vienne 337. 1906.
Uredo minima Schw. Schr. Nat. Ges. Leipzig 1:70. 1822.
Peridermium Peckii Thüm. Mitth. Forstl. Vers. Oest. 2:320 (24). 1880.
On Ericaceae: II.
Azalea viscosa L., Collins Beach, Oct. 1, 1907 (1910).

Fraser in 1910 (Mycol. 4:184. 1912) was the first to show that the alternate host for this species is *Tsuga canadensis*. He obtained suc-

cessful infection, resulting in pycnia and aecia on leaves and cones of *Tsuga canadensis* (referred to *Peridermium Peckii*) by sowings with telial material from *Rhodora canadensis*.

A comparison of the morphology of all the spore stages of this species with the following, taken together with the close relationship of the hosts involved, strongly suggests that they should be united under one name.

See also Phytopathology 8:329-330. 1918.

14. PUCCINIASTRUM MYRTILLI (Schum.) Arth. Result Sci. Congr. Bot. Vienne 337. 1906.

Aecidium Myrtilli Schum. Enum. Pl. Saell. 2:227. 1803.

ON VACCINIACEAE: II.

Vaccinium vacillans, Kalm., Newark, Sept. 17, 1907 (2008); Selbyville, Oct. 4, 1907 (1989).

Clinton (Rep. Conn. Agr. Exp. Sta. **1909-1910**:719. 1911) was the first to show that the aecial stage of this species occurred on *Tsuga canadensis*. He successfully infected *Gaylussacia baccata* by sowing with aeciospores from Tsuga, resulting in the development of the typical uredinia of this species.

Fraser in 1912 (Mycol. 5:237. 1913) confirms Clinton's work by obtaining the development of aecia on the leaves of *Tsuga canadensis* following sowings from teliosporic material on *Vaccinium canadense*. The same author in 1913 (Mycol. 6:27. 1914) obtained aecia on *Tsuga canadensis* following sowing of teliosporic material from *Galussacia resinosa*. The aecia developed in these experiments are similar to those of *Peridermium Peckii* Thüm. but may represent an undescribed form.

15. PUCCINIASTRUM PYROLAE (Pers.) Dietel, in Engler & Prantl Nat. Pfl. 1,1**:47. 1897.

Aecidium Pyrolae Pers. Gmel. Syst. Nat. 2:1473. 1791.

ON PYROLACEAE:

Chimaphila maculata (L.) Parsh., Seaford, June 5, 1908. (2075).

16. PUCCINIASTRUM PUSTULARUM (Pers.) Dietel, in E. & P. Nat. Pfl. 1,1**:47. 1897.

Uredo pustulata Pers. Syn. Fung. 219. 1801.

Pucciniastrum Epilobii Otth. Mitth. Nat. Ges. Bern **1861**:72. 1861.

Pucciniastrum Abieti-Chamaenerii Kleb. Jahrb. Wiss. Bot. 34:387. 1900.

ON ONAGRACEAE: II.

Epilobium coloratum Muhl., Mt. Cuba, Sept. 20, 1893, A. Commons (2262).

Klebahn (Zeits. Pflanzenkr. 9:22-26. 1899) and other European investigators have shown that the aecial stage of the rust on species of Epilobium belonging to the section Chamaenerion occurs in Europe on *Abies pectinata.*

Fraser in 1910 (Mycol. 4:176. 1912) was the first in America to record successful cultural experiments with this species. He showed that the aecia were found on *Abies balsamea* using for infection telia from *Epilobium angustifolium* collected in Nova Scotia. The aeciospores thus produced were used to infect *Epilobium angustifolium* and the typical uredinia of this species resulted. Weir and Hubert (Phytopath. 6:373. 1916) using telial material from the same host collected in Idaho obtained development of pycnia on *Abies lasiocarpa.*

It will be noted that all the cultural work has been conducted with but one American species of Epilobium which belongs in the same group as those successfully cultured in Europe. It is probable that there are at least two distinct biological races involved. Sydow (Monog. Ured. 3:442-444. 1915) recognizes two species.

See also Phytopathology 8:328-329. 1918 for a review of more recent work.

17. UREDINOPSIS ATKINSONII Magn. Hedwigia 43:123. 1904.

ON POLYPODIACEAE:

Dryopteris Thelypteris (L.) A. Gray, Stanton, July 13, 1894, A. Commons (2471).

Fraser in 1912 (Mycol. 5:236. 1913) proved that this species has its aecial stage on *Abies balsamea* (*Peridermium balsameum* Pk. p. p.) by successfully infecting *Dryopteris Thelypteris* with aeciospores from *Abies balsamea* with production of uredinia.

18. UREDINOPSIS MIRABILIS (Pk.) Magn. Hedwigia 43:121. 1904.

Septoria mirabilis Pk. Ann. Rep. N. Y. Mus. 25:87. 1873.

ON POLYPODIACEAE:

Lorinseria areolata (L.) Presl., Selbyville, Oct. 4, 1907, (1755).

Onoclea sensibilis L., Newark, Oct. 1907, (2259).

Fraser in 1910 (Mycol. 4:189. 1912) conducted inconclusive culture experiments indicating that this species on *Onoclea sensibilis* had for its aecial stage a Peridermium on *Abies balsamea.* In 1912 (Mycol. 5:236. 1913), however, the same author demonstrated conclusively that such was the case. Teliosporic material on *Onoclea sensibilis* L. was used to successfully infect the leaves of *Abies balsamea* resulting in pycnia and aecia of *Peridermium balsameum.* In three trials using aeciospores from *Abies balsamea,* uredinia developed on Onoclea. In 1913 (Mycol. 6:25. 1914) the results of 1912 were repeatedly confirmed. The species of the genus Uredinopsis are separated on rather slight morphological characters. Fraser reports the results of experiments, however, that indicate that this species is at least biologically distinct.

PUCCINIACEAE.

19. GYMNOCONIA INTERSTITIALIS (Schlecht.) Lag. Tromsö Mus. Aarsh. 16:140. 1894.

Caeoma interstitiale Schlecht. Horae Phys. Berol. 96. 1820.

Aecidium nitens Schw. Schr. Nat. Ges. Leipzig 1:69. 1822.

Puccinia Peckiana Howe; Peck, Ann. Rep. N. Y. State Mus. 23:57. 1872.

Puccinia tripustulata Peck, Ann. Rep. N. Y. State Mus. 24:91. 1872.

Gymnoconia Peckiana Trotter, Fl. Ital. Crypt. 1^{12}:338. 1910.

Kunkelia nitens Arth. Bot. Gaz. 58:504. 1917.

ON ROSACEAE: I.

Rubus allegheniensis Porter, Newark, May 1889, F. D. Chester.

Rubus villosus Ait., Newark, May 15, 1907, (1620), June 16, 1907, M. T. Cook, (1661).

Tranzschel (Hedwigia 32:257. 1893) was the first to report success in culturing this species. He succeeded in obtaining the development of *Puccinia Peckiana* Howe on *Rubus saxatilis* by sowing spores of *Caeoma nitens* Burrill.

In America Clinton (Bot. Gaz. 19:116. 1895) confirmed Tranzschel's work by successfully infecting *Rubus villosus* with production of telia. He used aecial material from the same host.

Kunkel (Bull. Torrey Club 40:361-366. 1913; Am. Jour. Bot. 1:37-47. 1914) has shown that *Caeoma nitens* on *Rubus frondosus* behaves

like a short cycle telial form comparable to Endophyllum, since the so-called aeciospores germinate like teliospores. In a later study (Bull. Torrey Club 43:559-569. 1916) Kunkel concludes that there are two forms of orange rust of Rubus in North America. He found that in certain collections the spores germinate as aeciospores with germ tube, while in others they germinate as teliospores. Arthur (l. c.) concurs in this view and establishes the genus Kunkelia for the short cycled form. Atkinson (Am. Jour. Bot. 5:79-83. 1918) presents evidence in support of the contention that only one species should be recognized and that it represents a form whose life history is unstable and that the spores may germinate either as aeciospores which on infection develop teliospores of *Puccinia Peckiana,* or as teliospores which, following infection, result in a repetition of the caeomoid aecial form. He considers that the behavior of the spores is dependent on certain conditions, the most important of which is temperature. Until more evidence is available it seems best to continue to list this species under the old name.

20. GYMNOSPORANGIUM BOTRYAPITES (Schw.) Kern, Bull. Torrey Club 35:506. 1908.

Caeoma Botryapites Schw. Trans. Am. Phil. Soc. II. 4:294. 1832.

Gymnosporangium biseptatum Ellis, Bull. Torrey Club 5:46. 1874.

ON JUNIPERACEAE: III.

Chamaecyparis thyoides (L.) B.S.P., Seaford, April 14, 1908.

Dr. W. G. Farlow (Anniv. Mem. Bost. Soc. Nat. Hist. 35:1880) was the first to attempt infection experiments with this species. He reports success in obtaining pycnia on *Crataegus tomentosa.* It is noteworthy that later studies have not confirmed the occurrence of the species on Crataegus. Later (Proc. Am. Acad. Nat. Sci. 12:313. 1885) spermogonia were obtained on leaves and stems of *Amelanchier canadensis.* Dr. R. Thaxter (Proc. Am. Acad. Nat. Sci. 14:263. 1887) obtained the development of aecia on *Amelanchier canadensis* which were recognized to be *Roestelia Botryapites* (Schw.) C. & E. These results were later repeatedly confirmed (Conn. Agr. Exp. Sta. Bull. 107:4. 1891).

Dr. J. C. Arthur (Mycol. 1:240. 1909) records successful infection of *Amelanchier intermedia* from telial material collected by the writer at Newfield, N. J., pycnia only resulting.

Dodge (Torreya 15:133-134. 1915; Bull. Torrey Club 42:519-542.

1915) conducted an extensive investigation of this species in comparison with *G. transformans*. In connection with this work he repeatedly obtained infection by using telia from galls on *Chamaecyparis thyoides*, on *A. canadensis*, *A. intermedia* and *A. Amelanchier* which resulted in the development of *Roestelia Botryapites*. (c. f. 27). He failed to obtain any infection on Aronia.

21. GYMNOSPORANGIUM CLAVARIAEFORME (Jacq.) DC. Fl. Fr. 2:217. 1895.

Tremella clavariaeformis Jacq. Coll. 2:174. 1788.

ON MALACEAE: I.

Amelanchier canadensis (L.) Medic., Felton, June 8, 1893, F. D. Chester.

The alternate host for this species occurs on *Juniperus communis* L. and *J. sibirica* Burgsd.

Oersted (Overs. Vid. Selsk. Forh. 210, 1867; Bot. Zeit. 222, 1867) was the first to carry out infection experiments with this species. He successfully infected *Crataegus oxycantha* following sowings with telial material. This species has since been frequently cultured by European investigators and the results have been fully summarized by Klebahn (Die Wirtswechselden Rostpilze 339-345. 1904).

In America, Thaxter (Proc. Am. Acad. Sci. 22:262. 1887; Bot. Gaz. 14:166. 1889) was the first to conduct definite cultures. He succeeded in obtaining the development of an abundance of pycnia and aecia on *Crataegus tomentosa* and *Amelanchier canadensis*.

Dr. J. C. Arthur (Jour. Myc. 14:19. 1908) in 1907 succeeded in obtaining infection of *Amelanchier intermedia* following sowings of sporidia from *Juniperus sibirica* with development of pycnia only. In 1908 (Mycol. 1:239. 1909) aecia were obtained on *Amelanchier erecta* following sowings of sporidia from *J. sibirica* from Colorado. In 1910, (Mycol. 4:24. 1912) using similar infection material, the same author succeeded in obtaining pycnia and aecia on *Amelanchier erecta* and pycnia on *Crataegus punctata*. In 1911 (Mycol. 4:56. 1912) the same results on *Amelanchier erecta* were obtained as in 1910, using telial material from the same locality. In 1913 (Mycol. 7:79. 1915) pycnia were obtained on *Crataegus cerronus*, following inoculation with telia from Colorado on *Juniperus sibirica*.

22. GYMNOSPORANGIUM GERMINALE (Schw.) Kern, Bull. Torrey Club 35:506. 1908.

Caeoma germinale Schw. Trans. Am. Phil. Soc. II. 4:294. 1832.

Gymnosporangium clavipes Cooke & Peck; Cooke, Jour. Quek. Club 2:267. 1871.

Roestelia aurantica Pk. Bull. Buffalo Soc. Nat. Sci. 1:68. 1873.

ON MALACEAE: I.

Cydonia vulgaris (L.) Pers., Smyrna, July 15, 1895, comm. J. C. Stockley; Felton, Aug. 1897, F. D. Chester.

ON JUNIPERACEAE: III.

Juniperus virginiana L., Iron Hill, May 1897, F. D. Chester; Seaford, April 14, 1908, (2252).

Dr. W. G. Farlow was the first to conduct culture experiments with this species. In 1883 (Proc. Am. Acad. Sci. 20:313. 1885) using telia from *Juniperus virginiana* he succeeded in obtaining the development of pycnia on leaves of *Malus Malus, Aronia arbutifolia* and *Amelanchier canadensis*, but aecia did not develop.

Dr. R. Thaxter (Bot. Gaz. 11:236. 1886; Proc. Am. Acad. Sci. 22:264. 1887) conducted similar cultural work obtaining well developed aecia on *Amelanchier canadensis* and pycnia on *Malus Malus*.

Dr. J. C. Arthur in 1907 (Jour. Myc. 14:18. 1908) using material on *Juniperus sibirica* from Illinois secured infection on leaves of *Amelanchier intermedia* and on fruit of *A. erecta* with development of pycnia only. In 1908 the same author (Mycol. 1:239. 1909) using telial material from *J. virginiana* from Kentucky succeeded in developing pycnia and aecia on Crataegus sp. In 1909 (Mycol. 2:229. 1910) successful infection of *Amelanchier erecta* with development of aecia in abundance and of *Crataegus punctata* with development of pycnia only was obtained. Telial material from *J. sibirica* from Michigan was used in these experiments. In 1910, (Mycol. 4:24. 1912) using telial material from Wisconsin on *J. sibirica,* successful infection of *Amelanchier erecta* and *Crataegus tomentosa* was obtained resulting in abundant aecia in both cases. Aeciospores from the Amelanchier were used in June 1910 to inoculate *J. sibirica* resulting in the development of telia the following spring.

23. GYMNOSPORANGIUM GLOBOSUM Farl. Anniv. Mem. Boston Soc. Nat. Hist. 18. 1880.

ON MALACEAE: I.

Crataegus phaenopyrum (L. f.) Medic., Newark, Oct. 1888, F. D. Chester.

Dr. W. G. Farlow (Anniv. Mem. Boston Soc. Nat. Hist. 34:1880 and Proc. Am. Acad. N. S. 12:312. 1885) was the first to conduct infection experiments with this species. He succeeded in obtaining pycnia only on *Crataegus tomentosa, C. Douglasii, C. oxyacantha*, following sowings with telial material from *J. virginiana*. Dr. R. Thaxter (Proc. Am. Acad. Sci. 22:263. 1887; Bot. Gaz. 14:167. 1889) succeeded in obtaining infection resulting in aecia on *Crataegus coccinea* and *Malus Malus* and spermogonia on *Sorbus americana* and *Cydonia vulgaris.*

In a later report (Conn. Agr. Exp. Sta. Bull. 107:4. 1891) additional work is recorded confirming the previous results on *Malus Malus* and recording successful infection of *Sorbus americana* resulting in the development of aecia.

Dr. J. C. Arthur in 1906 (Jour. Myc. 13:200. 1907) using a telial material from *Juniperus virginiana* from Indiana obtained aecia on *Crataegus Pringlei.* Similar material from West Virginia gave aecia on *Sorbus americana* and pycnia on *Crataegus Pringlei* and *Malus coronaria.* In 1907, (Jour. Myc. 14:18. 1908) infection from telial material from Indiana resulting in aecia, was secured on *Malus Malus.* In 1908 (Mycol. 1:239. 1909) infection resulting in aecia was obtained on *Crataegus Pringlei,* using telial material from Massachusetts. Pycnia were also obtained on Crataegus sp. using telial material from Kentucky. In 1909 (Mycol. 2:229. 1910) successful infection resulting in aecia was obtained on *Crataegus coccinea* using infecting material from North Carolina.

24. GYMNOSPORANGIUM JUNIPERI-VIRGINIANAE Schw. Schr. Nat. Ges. Leipzig 1:74. 1822.

Gymnosporangium macropus Lk. in Willd. Sp. Pl. 6^2:128. 1825.
Aecidium pyratum Schw. Trans. Am. Phil. Soc. II. 4:309. 1832.
Roestelia pyrata Thax. Proc. Am. Acad. 22:269. 1887.

ON MALACEAE: I.

Pyrus coronaria L., Wilmington, Aug. 26, 1886, A. Commons.

Pyrus malus L., Felton, Sept. 5, 1907 (1737).

ON JUNIPERACEAE: III.

Juniperus virginiana L., Georgetown, May 18, 1892, F. D. Chester; Lincoln City, May 1906, H. S. Jackson.

The species recorded above is the common cedar-apple rust known throughout the eastern United States and is one of the serious apple diseases often, in epidemic years, causing enormous losses. An account of this disease in Delaware with a list of susceptible and immune varieties has been prepared by Chester (Del. Exp. Sta. Rep. 8:63-69. 1896).

Farlow in 1877 and 1883 (Aniv. Mem. Boston Soc. Nat. Hist. 35:1880; Proc. Am. Acad. 20:313, 314. 1885) was the first to attempt culture work with this species. He obtained incomplete proof of the life history. In 1886 Thaxter (Proc. Am. Acad. 22:257. 1887) first conducted cultures establishing the genetic relation of the common apple rust (*Roestelia pyrata*) and *G. macropus*. He succeeded in obtaining aecia on *Pyrus malus* following sowing of teliospores from *J. virginiana*. The results were repeated and confirmed in 1887 (Bot. Gaz. 14:166. 1889). Halsted in 1886 (Bot. Gaz. 11:190. 1886; Bull. Iowa Agr. Coll. Dept. Bot. 59. 1886) obtained infection on *Pyrus Iowensis* resulting in aecia.

Stewart and Carver in 1896 (Rep. N. Y. (Geneva) Exp. Sta. 14:535. 1896) conducted culture experiments in New York and Iowa and obtained infection of apples in New York using telia collected in Iowa as well as locally, with successful development of aecia on some varieties. In Iowa infection could only be obtained on wild crab when either New York or Iowa telia were used. The results are recorded in considerable detail and are exceedingly interesting and difficult of explanation.

In 1901 Pammel (Bull. Iowa Exp. Sta. 84:24. 1905) conducted cultural experiments and reports infection of *Pyrus Iowensis* and *Crataegus mollis* and *C. pinnatifida* with development of aecia using telial material from both New York and Missouri.

Arthur in 1905 (Jour. Myc. 12:13. 1906) using telial material from Iowa and North Carolina obtained infection resulting in abundant pycnia on the apple from both sources. In 1906 and 1907 and 1910 (Jour. Myc.

13:200. 1907; 14:17. 1908; Mycol. 4:24. 1912) pycnia were again obtained on apple following sowings from telial material from Indiana.

In 1915 Reed and Crabill (Tech. Bull. Va. Exp. Sta. 9:43-45. 1915) report the results of numerous infection experiments on different varieties of cultivated apples. Their experiments bring out strongly the well established fact that some varieties are susceptible and other relatively or totally immune. They also show that only young leaves are susceptible.

25. GYMNOSPORANGIUM MYRICATUM (Schw.) Fromme, Mycol. 6:229. 1914.

Caeoma (Aecidium) Myricatum Schw. Trans. Am. Phil. Soc. II. 4:294. 1832.

Podisoma Ellisii Berk. Grevillea 3:56. 1844.

Gymnosporangium Ellisii Farl., Ellis N. A. Fungi 271. 1879.

ON MYRICACEAE: I.

Myrica cerifera L., Seaford, July 9, 1907 (1648).

ON JUNIPERACEAE: III.

Chamaecyparis thyoides (L.) B. S. P., Seaford, April 14, 1908 (2251).

Fromme (l. c.) has shown by infection experiments and field observations that the well known *Gymnosporangium Ellisii* has for its aecial stage *Aecidium Myricatum.* This is especially remarkable since only one other Gymnosporangium *(G. Blasdaleanum)* has been definitely shown by infection experiments to have aecia of the cupulate type, and since no other species of Gymnosporangium is known to have an aecial host in other than the Rosales.

26. GYMNOSPORANGIUM NIDUS-AVIS Thaxter, Bull. Conn. Exp. Sta. 107:6. 1891.

ON JUNIPERACEAE: III.

Juniperus virginiana L., Lewes, April 15, 1908 (2243).

This species produces largely "witches' brooms" on the red cedar.

Thaxter conducted culture experiments in 1886 and in 1887 (Proc. Amer. Acad. 22:264. 1887; Bot. Gaz. 14:167. 1889) in which he infected *Amelanchier canadensis* with production of pycnia and aecia in abundance using sporidia of the above species, at that time undescribed, but referred to *G. conicum.* In 1891 Thaxter (l. c.) stated "infections with

this species have been conducted every year since the spring of 1886 . . . and the results in all the cultures were identical."

Arthur in 1907 (Jour. Myc. 14:19. 1908), using sporidia from *J. virginiana* collected in Illinois, obtained successful infection of *Malus Malus* with production of pycnia followed by aecia, but failed to obtain infection of *Amelanchier intermedia.* In 1909 (Mycol. 2:230. 1910) successful infection of *Crataegus Pringlei* with production of pycnia only, and of *Malus Iowensis* with development of aecia was obtained, but without infection on *Amelanchier canadensis.* In 1910 (Mycol. 4:25. 1912) infection of *Cydonia vulgaris* and *Amelanchier vulgaris* with production of pycnia only is recorded. In 1911 (Mycol. 4:56. 1912) using sporidia from New Jersey successful infection of *Amelanchier erecta* resulted in the production of aecia on fruits; using sporidia from Nebraska successful infection of *Malus coronaria* with production of pycnia only is recorded. In 1914 (Mycol. 7:83. 1915) *Amelanchier vulgaris* was inoculated with telial material from Massachusetts and abundant production of pycnia and aecia resulted.

27. GYMNOSPORANGIUM TRANSFORMANS (Ellis) Kern, Bull. N. Y. Bot. Gard. 7:463. 1911.

Roestelia transformans Ellis; Peck, Bull. Torrey Club 5:3. 1874.

Gymnosporangium fraternum Kern, Bull. N. Y. Bot. Gard. 7:439. 1911.

ON MALACEAE: I.

Aronia arbutifolia (L. f.) Ell., Seaford, June 1908 (2262).

The above collection is of pycnia only.

Dodge (Torreya 15:133-134. 1915; Bull. Torrey Club 42:519-542. 1915) has studied the foliicolous form occurring on *Chamaecyparis thyoides* which until Kern's monographic study (l. c.) had been considered a form of *G. biseptatum.* His work clearly shows that this leaf form has for its aecia *Roestelia transformans* on Aronia having repeatedly obtained infection followed by development of aecia on *A. arbutifolia* and *A. nigra.* He also claims to have obtained infection with the leaf form on *Amelanchier intermedia, A. canadensis* and *A. Amelanchier,* resulting in the development of aecia having the morphology of *R. Botryapites* which has been repeatedly shown to go to the branch form known commonly as *G. biseptatum.* The young infections of *G. bisep-*

tatum which occur on the young twigs may easily be confused with the leaf form unless microscopically examined, and might have been mixed with the material of *G. fraternum* used in the infection experiments.

28. PHRAGMIDIUM AMERICANUM Diet. Hedwigia 44:124. 1905.

ON ROSACEAE:

Rosa Carolina L. Collins Beach, Oct. 1, 1907.

Rosa humilis Marsh., Seaford, June 4, 1908 (2050); Lewes, Aug. 14, 1907 (1685).

29. PHRAGMIDIUM DISCIFLORUM (Tode) J. F. James, Cont. U. S. Nat. Herb. 3:276. 1895.

Ascophora disciflora Tode, Fungi Meckl. 1:16. 1790.

ON ROSACEAE:

Rosa sp. (cultivated), Newark, September 1888, F. D. Chester.

30. PHRAGMIDIUM DUCHESNEAE (Arth.) Sydow, Monog. Ured. 3:93. 1912.

Kuehneola Duchesneae Arthur, N. A. Flora 7:185. 1912.

Frommea Duchesneae Arthur, Bull. Torrey Club 44:504. 1917.

ON ROSACEAE:

Duchesnea Indica (Ards.) Focke, II, Newark, May 1908, H. S. Jackson; III, Wilmington, Nov. 1, 1890, A. Commons (1686).

This species and the following possess only uredinia (primary and secondary) and telia in their life cycle differing from the commoner species occurring on Rubus and Rosa in the absence of any Caeoma stage. As suggested by Arthur (Phytopath. 6:100. 1916; Bull. Torrey Club 44:501-511. 1917) their affinities are with Phragmidium rather than with Kuehneola which doubtless belongs in the Uredinaceae. In the classification of the Uredinales based on the length of life cycle, proposed by Arthur (Result. Sci. Congr. Bot. Vienna in 1906) these species would represent a genus in the Phragmidiatae bearing the same relation to Phragmidium and Earlea that Bullaria does to Dicaeoma and Dasyspora in the Dicaeomatae. Frommea Arthur (l. c.) has been proposed as the name of this genus.

31. PHRAGMIDIUM TRIARTICULATUM (B. & C.) Farl., Bull. Bussey Inst. 1:433. 1876.

Aregma triarticulatum Berk. & Curtis; Berk. Grevillea 3:51. 1874.

Kuehneola obtusa Arthur N. A. Flora 7^3:185. 1912. p. p.

Phragmidium Potentillae-canadensis Diet. Hedw. Beibl. 42:179. 1903.
Frommea obtusa Arth. Bull. Torrey Club 44:503. 1917.
ON ROSACEAE:
Potentilla canadensis L., Newark, September 1907 (2004).

32. PILEOLARIA TOXICODENDRI (Berk. & Rav.) Arth. N. A. Flora 7[2]:147. 1907.
Uromyces Toxicodendri Berk & Rav. Grevillea 3:56. 1874.
ON SAPINDACEAE:
Rhus radicans L., Stanton, Sept. 10, 1885, A. Commons (184).

33. POLYTHELIS FUSCA (Pers) Arth. Result Sci. Congr. Bot. Vienne 341. 1906.
Aecidium fuscum Pers. Linn. Syst. Nat. 2[2]:1873. 1791.
Puccinia fusca Wint. Rabh. Krypt. Fl. 1:199. 1884.
ON RANUNCULACEAE:
Anemone quinquefolia L., Newark, April 13, 1908, (2255).

The mycelium of this species is perennial as first shown by DeBary (Monatsber. K. Akad. d. Wiss. Berlin 1865). Plants affected by this rust are deformed, slightly dwarfed and seldom if ever flower. The leaves are paler and narrower than normal and are considerably thickened.

34. PUCCINIA AGROPYRI E. & E. Jour. Myc. 7:131. 1892.
ON POACEAE:
Agropyron repens L., Newark, August 23, 1907 (1716).

No successful culture work has been conducted with this sub-epidermal leaf rust on this host. It is indistinguishable from the normal form of *P. tomipara* Trel. on Bromus sp. and with other similar forms on various grasses described under a variety of names including *P. obliterata* Arth. on *Agropyron* sp., *P. alternans* Arth. on *Bromus* sp. and *P. cinerea* Arth. on Poa sp. Considerable culture work has been done by Arthur showing that these forms have aecia on Ranunculaceae and are probably identical. It is to be expected that aecia for leaf rust on *Agropyron repens* will also be found to be on Ranunculaceae. The most probable connection is with Clematis.

35. Puccinia Aletridis B. & C. Grevillea 3:52. 1874.

On Liliaceae:

Aletris farinosa L., Newark, April 7, 1892, A. Commons (1924); Townsend, Oct. 9, 1896, A. Commons (2785); Selbyville, Oct. 3, 1907 (1756).

The specimen from Newark collected by Commons which is in the Ellis collection at the New York Botanical Garden is labeled as occuring on Chamalerion. The host is clearly Aletris.

No aecia are known for this rather rare species and its life history is in doubt. Only three other collections have been seen by the writer from Massachusetts, Florida and Mississippi.

36. Puccinia Anemones-Virginianae Schw. Schrift. Nat. Ges. Leipzig 1:72. 1822.

On Ranunculaceae:

Anemone virginiana L., Faulkland, Aug. 13, 1886, A. Commons (293).

The above collection was also issued in Ellis & Ev. N. A. Fungi 1847.

37. Puccinia Andropogonis Schw. Trans. Am. Phil. Soc. II, 4:295. 1834.

Aecidium Pentastemonis Schw. Schr. Nat. Ges. Leipzig 1:68. 1822.

On Scrophulariaceae: I.

Melampyrum lineare Lam. (*M. americanum* Michx.), Seaford, June 4, 1908 (2051).

On Poaceae: II, III.

Schizachyrium scoparium (Michx.) Nash (*Andropogon scoparius* Michx.), Lewes, Nov. 16, 1907.

This species on Andropogon was first cultured by Arthur in 1899 (Bot. Gaz. 29:27. 1900) who succeeded in obtaining infection, resulting in aecia on *Pentstemon pubescens* using telia from *A. scoparius* from Indiana. In 1904 and 1906 the same author (Jour. Myc. 10:11. 1904; 13:197. 1907) using telia of *A. scoparius* collected in Nebraska, obtained infection resulting in aecia on *P. hirsutus*. In 1910 (Mycol. 4:17. 1912) telia from *A. virginicus* from W. Virginia were successfully cultured on *P. hirsutus* and from *A. scoparius* from Colorado on *P. alpinus*. In 1903 Kellerman (Jour. Myc. 9:10. 1903) verified the results of Arthur by obtaining successful infection on *P. hirsutus* resulting in pycnia following sowing of telia from *A. scoparius* collected in Indiana.

This aecidium on Melampyrum included here is known on this host otherwise only from Connecticut and Massachusetts. It somewhat resembles *A. Melampyri* Kuntze & Schum., which has been shown by Juel (Obv. K. Vet. Akad. Föch 1894. 503) and Klebahn (Kulturv. VIII 402) to go to *Puccinia nemoralis* Juel on *Molina caerulea.* The American aecia differs however from the European in the larger thick walled aeciospores and in the character of the peridial cells and since no telial form referrable to the European species has yet been found in America it is probable that the Aecidium under discussion goes to some American grass or sedge rust. It is scarcely distinguishable from the aecia of *P. Andropogonis* Schw. which occur on other Scrophulariaceae in the same range and is tentatively referred here till positive cultures are conducted.

38. PUCCINIA ANGUSTATA Pk. Bull. Buff. Soc. Nat. Hist. 1:67. 1873.

Aecidium lycopi Ger.; in Peck Bull. Buff. Soc. Nat. Hist. 1:68. 1873.

ON BORAGINACEAE: I.

Lycopus virginicus L., Newark, May 25, 1908, (2236), Seaford, June 4, 1908, (2068).

ON CYPERACEAE: II, III.

Scirpus atrovirens Muhl. Newark, Oct. 4, 1905, (1635).

Scirpus cyperinus (L.) Kunth., Selbyville, October 4, 1907, (1812).

Scirpus georgianus Harper, Newark, September 1907, (1818, 1820).

This species has for its aecial stage *Aecidium lycopi* Ger. on Lycopus sp. as first shown by Arthur in 1899 (Bot. Gaz. 29:273. 1900), who succeeded in infecting *Scirpus atrovirens* with aeciospores from *Lycopus americanus.* These results were confirmed in 1901, 1903, 1904, 1906 and 1907 (Jour. Myc. 8:53. 1902; 11:58. 1905; 13:196. 1907; 14:14. 1908) by sowing teliospores from *Scirpus atrovirens* on leaves of *Lycopus americanus* resulting in each case in the development of aecia. Kellerman in 1903 (Jour. Myc. 9:226. 1903) confirms Arthur's results using the same hosts, collecting his telial material in Ohio. In 1908 (Mycol. 1:234. 1909) Arthur infected *Lycopus communis* and *L. americanus* by sowing with teliospores from *Scirpus cyperinus.* In 1910 (Mycol. 4:17. 1912) the results of 1901-1907 were confirmed and in 1911 (Mycol. 4:54.

1912) the results of 1908 were confirmed in part. In 1912 (Mycol. 7:70. 1915) infection resulting in the development of aecia was again obtained on *L. americanus* using telial material on *S. atrovirens* from Indiana and Ontario.

39. PUCCINIA ANTHOXANTHI Fckl. Symb. Myc. Nachtr. 2:15. 1873.
   ON POACEAE:
      Anthoxanthum odoratum L., Newark, June 1908, (2244).

40. PUCCINIA ASPARAGI DC. Flora Fr. 2:595. 1805.
   ON CONVALLARIACEAE:
      Asparagus officinalis L., Hare's Corners, October 1896, F. D. Chester; Smyrna, October 1904, C. O. Smith; Lewes, Aug. 14, 1907, (1681).

A discussion of the economic importance of this rust in Delaware will be found in Delaware Experiment Station bulletins 57 and 63.

Sheldon (Science N. S. 16:235. 1902) shows that this species is autoecious and that the urediniospores may carry the fungus over the winter. He also claims to have successfully infected *Allium cepa*, all three stages having been produced on that host.

41. PUCCINIA ASPERIFOLII (Pers.) Wettst. Verh. Zool.-Bot. Ges. Wein. 35:541. 1885.
   Puccinia dispersa Erikss. Zeitsch. f. Pflanzkr. 4:257. 1894.
   Aecidium asperifolii Pers. Obs. Myc. 1:97. 1896.
   ON POACEAE:
      Secale cereale L., Newark, May 25, 1908, (2263).

DeBary (Monatsber. K. Akad. d. Wiss. Berlin 211. 1866) was the first to show the connection between the leaf rust of rye and *Aecidium asperifolii* Pers. by sowing sporidia on *Anchusa officinalis* L. and on *Lycopsis arvensis*, pycnia and aecia resulting. Uredinia and telia were obtained on rye following sowing of aeciospores from the above mentioned aecial hosts.

In America, Arthur (Mycol. 1:236. 1909) records successful infection experiments resulting in the production of pycnia on *Lycopsis arvensis* L. following sowings of sporidia from *Secale cereale* L. The Lycopsis plants were grown from seed secured in Europe. These cultures prove that the leaf rust of rye in Europe and America is identical.

42. PUCCINIA ASTERIS Duby, Bot. Gall. 2:888. 1830.

ON CARDUACEAE:

Aster paniculatus Lam., Newark, September 1905, (1636); September 10, 1907, (1728).

Aster salicifolius Lam., Newark, September 10, 1907, (1728).

43. PUCCINIA ASTERUM (Schw.) Kern, Mycol. 9:224. 1917.

Aecidium asterum Schw. Schr. Nat. Ges. Leipzig 1:67. 1822.

Puccinia extensicola Plowr. British Ured. & Ust. 181. 1889.

Puccinia vulpinoidis Diet. & Holw.; Dietel, Bot. Gaz. 19:304. 1894.

Puccinia Caricis-Erigerontis Arth. Jour. Myc. 8:53. 1902.

Puccinia Caricis-Asteris Arth. Jour. Myc. 8:54. 1902.

Puccinia Caricis-Solidaginis Arth. Bot. Gaz. 35:21. 1903.

Puccinia Dulichii Syd. Monog. Ured. 1:684. 1903.

ON CARDUACEAE: I.

Erigeron annuus (L.) Pers., Newark, June 1907, (1669).

Euthamia graminifolia (L.) Nutt., Seaford, June 4, 1908, (2043, 2065).

Solidago altissima L., June 5, 1908, (2076).

Solidago rugosa Mill., Seaford, June 9, 1907, (2013, 2014).

Solidago sempervirens L., Seaford, June 4, 1908, (2086).

ON CYPERACEAE: II, III.

Carex albolutescens Schw., Selbyville, Oct. 4, 1907, (1808, 1809).

Carex festucacea Willd., Seaford, Nov. 15, 1907, (1759).

Carex Leersii Willd., Seaford, June 4, 1908, (2057a, 2061b).

Carex Muhlenbergii Schk., Lewes, Aug. 14, 1907, (1699).

Carex radiata (Wahl) Small, Newark, Sept. 1907, (1826).

Carex rosea Schk., Seaford, June 4, 1908, (2062a).

Carex stipata Muhl., Newark, Sept. 1907, (1821, 1827).

Carex straminea Willd., Seaford, Nov. 14, 1907, (1770), Nov. 15, 1907, (1859).

Carex vulpinoidea Michx., Lewes, Aug. 16, 1907, (1678); June 7, 1908, (2087); Collins Beach, Oct. 1, 1907, (1783); Newark, Aug. 23, 1907, (1717, 1725), Sept. 1907, (1733), April 5, 1908, April 11, 1908, Felton, Sept. 5, 1907, (1740, 1741); Seaford, April 23, 1908, (2032), June 4, 1908, (2077, 2080, 2081).

Dulichium arundinaceum (L.) Britt., Selbyville, Oct. 4, 1907, (1803, Barth. Fungi Columb. 2662); Seaford, Nov. 14, 1907, (1761).

In 1901 Arthur (Jour. Myc. 8:54. 1902) first began culture work showing that aecia which occur commonly on Aster, Solidago and related hosts are genetically connected with uredinia and telia on various species of Carex. The culture work conducted by Arthur is extensive and extends over a period of years from 1901-1914. In this series of culture work aecia have been produced on various species of Aster, Solidago, Erigeron, Leptilon and Euthamia, using telia from many species of Carex from various parts of North America and from Dulichium. (Jour. Myc. 8:54. 1902; 11:58. 1905; 12:15. 1906; 14:13. 1908; Bot. Gaz. 35:15, 21. 1903; Mycol. 1:233. 1909; 2:224. 1910; 4:15, 16. 1912; 7:70, 81. 1915). Fraser in 1911 (Mycol 4:181. 1912) confirms Arthur's results in part by successfully infecting *Aster acuminatus* using telial material from *Carex trisperma*.

This study has also shown that the species as here considered is a composite form made up of several distinct physiological races.

The species is separable from all other American species of Puccinia on Carex by the presence of two pores in the upper part of the rather small (12-19 by 16-23μ) uredospores, and the medium sized (12-20 by 35-50μ) teliospores.

44. PUCCINIA BATESIANA Arth. Bull. Torrey Club 28:661. 1901.

ON CARDUACEAE:

Heliopsis helianthoides (L.) B. S. P., Newark, Oct. 4, 1905, (1510).

This species has not been recorded otherwise on this host but has been collected in Iowa, Minnesota and Nebraska on *Heliopsis scabra* Dunal.

45. PUCCINIA VERNONIAE Schw. Proc. Am. Phil. Soc. II. 4:296. 1832.

Puccinia bullata Schw. Schrift. Nat. Ges. Leipzig 1:74. 1822.

ON CARDUACEAE:

Vernonia noveboracensis (L.) Willd., Clayton, July 24, 1907, (1707).

This very common species is apparently confined to the United States and is the only one so far recorded north of Mexico. The name

first proposed by Schweinitz was based on collections made at Salem, North Carolina, occurring "erumpent from the dried stems of various plants, e. g. Ambrosia, Chenopodium." In his later publication he cites it as occurring in Pennsylvania on *V. noveboracensis*. An examination of the material in the Schweinitz collection at the Philadelphia Academy of Science, made by Dr. J. C. Arthur, shows that there are three packets, containing in the aggregate 9 pieces, of similar stems bearing large sori up to 3 cm. long. The original packet reads "P bullata LvS. Salem & Beth. in caulibus varies." The stems all appear to be of Vernonia and the rust when examined microscopically does not differ from similar material on Vernonia stems (now interpreted as *V. altissima*) collected by L. M. Underwood at Fern, Putnam Co., Indiana, and distributed in Ellis & Ev. N. A. Fungi 2988 and other exsiccati under the name *P. Vernoniae* Schw. No other rust with which this could possibly be confused is known to occur on the stems of Ambrosia or Chenopodium, or on any other host within the range of this species.

That the rust on the stems is the same as the more common, or at least more frequently collected, form on the leaves has been shown by Dr. Arthur who, in 1916, using telial material from the stems of Vernonia sp. collected by C. H. Crabill at Cliffview, Va., and communicated by Dr. F. D. Fromme, succeeded in obtaining the development of pycnia and uredinia on the leaves of Vernonia sp. This culture also demonstrates that this rust, whose life history has long been in doubt, is a brachy-form referrable to the genus Bullaria. Pycnia have not been observed in any field collections thus far studied.

46. PUCCINIA CANALICULATA (Schw.) Lagerh. Tromsö Mus. Aarsh. 17:51. 1894.

Sphaeria canaliculata Schw. Trans. Am. Phil. Soc. II, 4:209. 1832.

Aecidium compositarum Xanthii Burr.; DeToni in Sacc. Syll. Fung. 7:799. 1888.

ON CARDUACEAE: I.

Xanthium echinatum Murr., Seaford, June 4, 1908, (2049).

ON CYPERACEAE: II, III.

Cyperus esculentus L., Selbyville, Oct. 4, 1907, (1794).

Cyperus filiculmis Vahl., Felton, Sept. 5, 1907, (1742).

Cyperus lancastriensis Porter, Selbyville, Oct. 4, 1907, (1813).

Cyperus ovularis (Michx.) Torr., Felton, Sept. 5, 1907, (1744); Newark, Oct. 20, 1907, (2258).

Cyperus refractus Engelm., Newark, Aug. 23, 1907, (1718).

Cyperus strigosus L., Felton, July 30, 1906, (1618); Lewes, Aug. 14, 1907, (1693).

Cyperus Torreyi Britton (*C. cylindricus* (Ell.) Britton), Selbyville, Oct. 4, 1907, (1810).

Arthur (Jour. Myc. 12:23. 1906) conducted culture experiments in 1905 which showed that an aecidium on *Xanthium canadense* is connected with this species on various species of Cyperus. Following sowings of aeciospores from *X. canadense*, collected in Indiana, urediniospores developed on *C. esculentus*.

47. Puccinia Caricis-strictae Dietel, Hedw. 28:23. 1889.

Uromyces Caricis Pk. Ann. Rep. N. Y. State Mus. 24:90. 1872.

On Cyperaceae: II, III.

Carex stricta Lam., Seaford, Nov. 14, 1907, (1757, 1762, 1763, 1764, 1765, 1766).

48. Puccinia Chrysanthemi Roze, Bull. Soc. Myc. Fr. 17:92. 1900.

On Carduaceae:

Chrysanthemum sinense Sabine, Camden, September 1905, (1536); Wyoming, November 1907.

This rust causes considerable damage to cultivated chrysanthemums. The life history is somewhat in doubt. In America the rust exists only in the uredinial stage.

49. Puccinia Cirsii Lasch. in Rab. Fungi Eur. 89. 1859.

On Carduaceae:

Carduus altissimus L., Faulkland, Oct. 20, 1886, A. Commons, 459; August 1887, A. Commons, 137.

The latter specimen was issued in E. & E. N. A. Fungi 2253 as *P. compositarum* Schlecht, f. *Cnici altissimi*. This is a brachy-Puccinia developing pycnia with the uredinia and occurs most commonly on the under surface of the leaves. It occurs throughout the United States on species of Carduus other than *C. lanceolatus*.

50. PUCCINIA CLAYTONIATA (Schw.) Peck, Bull. N. Y. State Mus. 6:226. 1899.

Caeoma (Aecidium) claytoniatum Schw. Tran. Am. Phil. Soc. II. 4:294. 1832.

Puccinia Mariae-Wilsoni G. W. Clinton, Bull. Buff. Soc. Nat. Sci. 1:166. 1873.

Allodus claytoniata Arth. Result. Sci. Congr. Bot. Vienna 345. 1906.

ON PORTULACACEAE:

Claytonia virginica L., Newark, May 2, 1907, I, (1578); May 29, 1907, III, (1658); April 19, 1908, I, (2241).

Orton (Mem. N. Y. Bot. Gard. 6:177. 1916) is the authority for the statement that this species has been cultured by Fromme. He sowed aeciospores from primary aecia on the same host and obtained the development of telia of the scattered type indicating that repeating aecia do not occur in this species. An examination of specimens in the Arthur herbarium has failed to reveal any collection of aecia not accompanied by pycnia.

51. PUCCINIA CNICI Mart. Fl. Mosq. 226. 1817.

Puccinia Cirsii-lanceolati Schroet. Pilze Schles. 1:317. 1887.

ON CARDUACEAE:

Carduus lanceolatus L., Newark, October 1907, (2009).

This species produces aecia of a peculiar character having a rudimentary aecidium. All stages occur most abundantly on the upper surfaces of the leaves.

Kellerman (Jour. Myc. 9:229. 1903) has shown through carefully conducted culture experiments that this species is an eu-Puccinia and autoecious. In America it is known only on the above host.

52. PUCCINIA CONVOLVULI (Pers.) Cast. Obs. Myc. 1:16. 1842.

Uredo Betae Convolvuli Pers. Syn. Fung. 221. 1801.

ON CONVOLVULACEAE:

Convolvulus sepium L., Wilmington, Aug. 17, 1886, III, A. Commons (302); Lewes, April 1908, I, (2260).

The collection by Commons was issued in E. & E. N. Am. Fungi 1857 as on *Ipomoea pandurata* (L.) Meyer. The host is certainly Convolvulus. Arthur (Bot. Gaz. 29:270. 1900) has shown that this species

is autoecious. Teliospores from *C. sepium* were sown in the greenhouse on the same host with subsequent abundant development of pycnia and aecia.

53. PUCCINIA CRYPTOTAENIAE Pk. Rep. N. Y. State Mus. 25:114. 1873.

ON AMMIACEAE:

Deringia canadensis (L.) Kuntze, Wilmington, Nov. 14, 1888, A. Commons (909); Newark, May 1907, (1667).

This is a micro-Puccinia correlated with *Puccinia microica* Ellis which is an opsis form. The latter was originally reported as occurring on Sanicula sp., which was an error for *Deringia canadensis*.

54. PUCCINIA CYANI (Schleich.) Pass. Rabh. Fungi Eur. 1767. 1874.

Uredo Cyani Schleich. Pl. Helv. 95.

ON CARDUACEAE:

Centaurea cyanus L., Newark, May 20, 1913, C. O. Houghton.

55. PUCCINIA EATONIAE Arth. Jour. Myc. 10:18. 1904.

Aecidium Ranunculi Schw. Schr. Nat. Ges. Leipzig 1:67. 1822. (Not *A. Ranunculi* Schum. 1803.)

ON RANUNCULACEAE: I.

Ranunculus abortivus L., Newark, May 1, 1905, C. O. Smith. Issued as *A. Ranunculi* Schw. in E. & E. Fungi Columb. 2107. Newark, May 1, 1908, (2238).

ON POACEAE: II, III.

Sphenopholis pallens (Spreng.) Schrib., Newark, May 1, 1908, II, (2237), June 1, 1908, III (2234, 2239).

Sphenopholis nitida (Spreng.) Schrib., Newark, June 1908, (2269).

Arthur in Jour. Myc. 10:18. 1904, shows by culture that *Aecidium Ranunculi* Schw. has its telial stage on *Sphenopholis pallens* (*Eatonia pennsylvanica* (DC.) A. Gray), having obtained infection on *E. pennsylvanica* resulting in uredinia by inoculation with aeciospores from *Ranunculus abortivus*. Field observations made by the writer in connection with the collections listed above lend confirming evidence to the cultural results by Dr. Arthur. On May 1 the writer collected *Aecidium Ranunculi* Schw. (2238). Almost in contact were found the leaves of grass at that time not yet fruiting, bearing fresh uredinia (2237). The

over-wintering leaves of this grass were found to bear telia. On June 1 at the same place this grass was found in fruiting condition bearing fresh telia (2239). The grass proved to be *Eatonia pallens*. Examination showed the rust to be that described by Arthur on *P. Eatoniae*.

56. PUCCINIA ELEOCHARIDIS Arth. Bull. Iowa Agr. College Nov. 156. 1884.

Aecidium compositarum Eupatorii DeToni in Sacc. Syll. Fung. 7:798. 1888.

ON CARDUACEAE: I.

Eupatorium perfoliatum L., Seaford, June 4, 1908, (2054, 2061a, 2074, 2079).

Eupatorium purpureum L., Seaford, June 4, 1908, (2058b, 2060, 2062b, 2067, 2072).

Eupatorium rotundifolium L., Seaford, June 4, 1908, (2055, 2069).

Arthur conducted culture experiments in 1905 (Jour. Myc. 12:23. 1906) showing that an aecidium resembling in every way the common one on Eupatorium species could be induced by sowings with teliospores from Eleocharis. He used teliospores on *Eleocharis palustris* from Wisconsin to successfully infect *Eupatorium perfoliatum*, with subsequent development of aecia—two trials. These results were confirmed in 1906 and 1908 by the same author (Jour. Myc. 13:197. 1907; Mycol. 1:233. 1909) when typical aecia were produced on *Eupatorium perfoliatum* following infection by teliospores from *E. palustris* collected in Kansas and Indiana.

57. PUCCINIA ELLISIANA Thüm. Bull. Torrey Club 6:215. 1878.

Puccinia americana Lagerh. Tromsö Mus. Aarsh. 17:45. 1895.

ON POACEAE: II, III.

Andropogon scoparius Mchx., Newark, Oct. 1907 (1830); March 30, 1908, (2246).

This species has been separated from *P. Andropogonis* by the possession of thick walled verrucose uredospores.

Long (Phytopath. 2:164. 1912) carried on successful experiments with this species in 1910, 1911, and 1912 reporting successful infection of *Viola fimbriatula*, *V. hirsutula*, *V. sagittata*, *V. papilionacea*, with

development of aecia following sowings of teliospores from *A. virginicus.* Uredinia were produced on Andropogon when aecia were used for infection.

Arthur in 1912 (Mycol. 7:71. 1915) using telia from Andropogon sp. from North Dakota obtained the development of aecia on *V. cucullata* and *V. Nuttallii.*

In a later paper Long (Jour. Agr. Res. 2:303-319. 1914) presents the results of an extensive research dealing with this species and *P. Andropogonis* Schw. in which he claims to prove "that the ordinary Pentstemon rust *P. Andropogonis,* can be produced from the Viola rust *P. Ellisiana,* by simply passing the Viola rust through Pentstemon as an aecial host." Numerous culture experiments were conducted in support of the above conclusion.

58. PUCCINIA EMACULATA Schw. Trans. Am. Phil. Soc. II, 4:295. 1834.

ON POACEAE:

Panicum capillare L., Newark, Sept. 15, 1905, (1615); Felton, Sept. 5, 1907, (1750).

Successful cultures have never been conducted with this common rust though many attempts have been made. Morphologically it is very like *P. Pammelii* (Trel.) Arth. (*P. Panici* Diet.) and perhaps should be united with it. On account of the resemblance to that species the aecia should be looked for on Euphorbiaceous hosts. It is convenient, however, to retain it as a separate form till cultures establishing its relationship have been successfully carried out.

59. PUCCINIA EPIPHYLLA (L.) Wettst. in Verh. Zool.-Bot. Ges. Wien 35:541. 1886.

Lycoperdon epiphyllum L. Sp. Pl. 1653. 1753.

Aecidium Tussilaginis Pers. in Gmel. Syst. Nat. 2:1473. 1791.

Puccinia poarum Nielsen Bot. Tidsskr. III, 2:34. 1877.

ON POACEAE: II.

Poa annua L., Newark, June 1908, (2245).

Poa pratensis L., Seaford, June 4, 1908, (2053a, 2042); Newark, June 1908, (2268).

Nielsen was the first to show the relation between this rust and *Aecidium Tussilaginis.* He succeeded in infecting *P. annua, P. trivialis, P. nemoralis, P. fertilis* and *P. pratensis* by sowing aeciospores from

Tussilago farfara. He infected the aecial host by sowing with teliospores from *P. annua.*

Additional observations and culture work have been recorded by various European authors, which has been summarized by Klebahn (Die Wirtw. Rostpilze 290. 1904).

60. PUCCINIA FRAXINATA (Lk.) Arth. Bot. Gaz. 34:6. 1902.

Aecidium Fraxini Schw. Schr. Nat. Ges. Leipzig 1:66. 1822. (Not *A. Fraxini* Korn.)

Caeoma Fraxinatum Lk. in Willd. Sp. Pl. 6^2:62. 1825.

Puccinia Sparganioides Ellis & Barth. Erythea 4:2. 1896.

ON OLEACEAE: I.

Fraxinus lanceolata Borck., Newark, 1897, F. D. Chester, June 17, 1907, (1663); May 1908: (2240).

ON POACEAE: III.

Spartina cynosuroides (L.) Roth (*S. polystachya* Ell.), Collins Beach, Oct. 1, 1907, (1784).

Spartina stricta (Ait.) Roth (*S. glabra* Muhl.), Lewes, Nov. 16, 1907, (1772, 1773, 1849, 1850a, 1851); Collins Beach, Oct. 1, 1907, (1785, 1786).

The Aecidium on Fraxinus known as *A. Fraxini* Schw. was first shown by Arthur (Bot. Gaz. 29:275. 1900) to have telia on *Spartina cynosuroides.* He obtained the development of aecia on *F. viridis* following sowings of telial material from Iowa and Nebraska. In 1904, 1905, 1907 and 1909 (Jour. Myc. 11:57. 1905; 12:16. 1906; 14:14. 1908; Mycol. 2:225. 1910) similar results were obtained on *F. lanceolata* using telia from Iowa, Kansas, Nebraska and North Dakota.

In 1908 the writer sent telial material collected at Lewes on *S. cynosuroides* and *S. stricta* to Dr. Arthur for culture work. Successful infection of *F. lanceolata* with development of aecia was obtained from cultures with telia from both hosts.

61. PUCCINIA HELIANTHI-MOLLIS (Schw.) Jackson, Brooklyn Bot. Gard. Mem. 1:250. 1918.

Aecidium Helianthi-mollis Schw. Schr. Nat. Ges. Leipzig 1:68. 1822.

Puccinia Helianthi Schw. Schr. Nat. Ges. Leipzig 1:73. 1822.

ON CARDUACEAE:

Helianthus annuus L., Newark, Sept. 1907, (2006).

Helianthus angustifolius L., Selbyville, Oct. 4, 1907, (1993).

Helianthus decapetalus L., Newark, Sept. 7, 1905, (1553, 1624), Aug. 23, 1907, (1724).

Carleton (Science 13:250. 1901) was the first in America to record culture experiments showing that the species is autoecious. These results were confirmed by Arthur (Bot. Gaz. 35:17. 1903) whose work indicates, however, that there may be biological races. Further evidence of this was obtained in 1903 (Jour. Myc. 10:12. 1904) and in 1904 (Jour. Myc. 11:53. 1905), on further evidence, the conclusion is made that "*P. Helianthi* Schw. is a single species having many races, for which *H. annuus* acts as a bridging host." Further cultural results were recorded in Jour. Myc. 12:18. 1906.

62. PUCCINIA HIBISCIATUM (Schw.) Kellerm. Jour. Myc. 9:110. 1903.

Caeoma Hibisciatum Schw. Trans. Am. Phil. Soc. II, 4:293. 1834.

Aecidium Napaeae Arth. & Holw.; Arthur in Bull. Iowa Agr. Coll. 1884:166. 1885.

Aecidium Callirrhoes Ell. & Kellerm. Jour. Myc. 2:4. 1886.

Puccinia Muhlenbergiae Arth. & Holw. Bull. Lab. Nat. Hist. Univ. Iowa 5:317. 1902.

Puccinia tosta Arth. Bull. Torrey Club 29:228. 1902.

ON POACEAE: II, III.

Muhlenbergia sobalifera (Muhl.) Trin.,—Wilmington, Oct. 26, 1891, A. Commons (1867).

Muhlenbergia Schreberi Gmel. (*M. diffusa* Willd.),—Newark, Sept. 1907, (1817, 1828).

Kellerman (Jour. Myc. 9:110, 232. 1903) was the first to conduct successful culture experiments leading to an understanding of the life history of this species. An extensive series of inoculations with telial material on *Muhlenbergia mexicana* from Ohio, in which many Malvaceous hosts were used, resulted in obtaining successful infection of *Hibiscus mocheutos* and *H. militaris* with production of typical aecia of *A. Hibisciatum* Schw.

Arthur in 1908 (Mycol. 1:251. 1909) first showed that this species also has for its aecial stage, *A. Napaeae* A. & H. Infection of *Callirrhoe involucrata*, resulting in aecia, was obtained following sowings of teliospores from *M. mexicana* from Kansas. These results were confirmed

in 1909 (Mycol. 2:226. 1910) using telial material on *M. glomerata* from Kansas and in 1910 (Mycol. 4:18. 1912) successful infection followed sowings with teliospores from *M. racemosa* collected in North Dakota.

In 1914 (Mycol. 7:80. 1915) Arthur also showed that *Puccinia tosta* on *Sporobolus asperifolius* has for its aecial stage, *Aecidium Sphaeralceae*. Successful infection of *Sphaeralcea incana* was obtained following sowings of telial material from New Mexico. Infection of *S. lobata* was also obtained when telial material from Texas was used. A comparison of the aecia and of the telia showed *P. tosta* to be inseparable from the form of Muhlenbergia.

63. PUCCINIA HIERACII (Schum.) Mart. Flora Mosq. 226. 1817.

Uredo Hieracii Schum. Enum. Plant. Saell. 2:232. 1803.

ON CICHORIACEAE:

Hieracium scabrum Michx., Newark, Sept. 5, 1905, (1623); Lewes, April 25, 1908, (2035).

64. PUCCINIA IMPATIENTIS (Schw.) Arth. Bot. Gaz. 35:19. 1903.

Aecidium Impatientis Schw. Schr. Nat. Ges. Leipzig 1:67. 1822.

Puccinia perminuta Arth. Bull. Torrey Club 34:584. 1907.

ON BALSAMINACEAE: I.

Impatiens aurea Muhl., Newark, June 17, 1907, (1664).

ON POACEAE: II, III.

Agrostis hyemalis (Walt.) B. S. P., Seaford, June 4, 1908, (2045).

Agrostis perrenans (Walt.) Tuckerm. Woodland Beach, Aug. 1890, J. H. Holmes (Phan. spec. 312).

Elymus canadensis L., Newark, Aug. 23, 1907, II, (1722).

Arthur has shown that *Aecidium Impatientis* Schw. is connected with a telial form on *Elymus virginicus* L. which previously had been called *P. rubigo-vera* (Bot. Gaz. 35:18. 1903). He obtained the development of aecia on *Impatiens aurea* following inoculation with germinating teliospores on *Elymus virginicus* from Indiana. Further cultures made in 1903 and 1904 (Jour. Myc. 10:11. 1904; 11:57. 1905) gave identical results when telial material from Indiana and Wisconsin were used for inoculation. In 1909 (Mycol. 2:226. 1910) teliospores from *Elymus striatus* were used by Arthur to successfully inoculate *Impatiens*

aurea. Uredinia were also obtained on *E. virginicus*, *E. canadensis*, and *E. striatus* following infection with aeciospores from *Impatiens aurea.*

65. PUCCINIA IRIDIS (DC.) Wallr. Rabh. Krypt. Fl. Ed. 1, 1:23. 1844.
Uredo Iridis DC. Encycl. 8:224. 1808.
ON IRIDACEAE:
Iris versicolor L., Newark, July 24, 1906, (1565).

The life history of this common rust is still in doubt, only uredinia and telia are known.

66. PUCCINIA LOBELIAE Ger. Bull. Buffalo Soc. Nat. Sci. 1:68. 1873.
ON CAMPANULACEAE:
Lobelia puberula Michx., Wilmington, Sept. 1893, A. Commons, (issued also in E. & E. Fungi Columb. 261); Newark, Sept. 8, 1893, A. Commons, (2213).
Lobelia syphilitica L., Lewes, Aug. 14, 1907, (1696), August, 1907, (2242).

67. PUCCINIA LYSIMACHIATA (Link) Kern, Mycol. 9:215. 1917.
Aecidium Lysimachiae Schw. Schr. Nat. Ges. Leipzig 1:67. 1822.
Caeoma lysimachiatum Link, in Willd. Sp. Pl. 6^2:45. 1825.
Puccinia Limosae Magn. Amtl. Ber. Vers. Deutsch. Naturf. u. Aerzte 1877:200. 1877.
ON PRIMULACEAE: I.
Lysimachia terrestris (L.) B. S. P., Seaford, June 5, 1908, (2084).

Klebahn (Jahr. Wiss. Bot. 34:396. 1910) has shown that the European *A. Lysimachiae* Schlecht. is genetically connected with *P. Limosae* Magn. He succeeded in obtaining infection resulting in the development of urediniospores on *Carex limosa* following sowings with aeciospores from *Lysimachia thyrsiflora* and *L. vulgaris.* No cultures have been conducted in America, but since no essential morphological difference can be detected in the aecia and several collections on Carex have been recognized by Arthur which agree with European material referred to *P. Limosae*, there seems to be no good reason for considering the American form distinct from the European.

68. PUCCINIA MACROSPORA (Pk.) Arth. Mycol. 1:244. 1909.

Aecidium macrosporum Pk. Ann. Rep. N. Y. State Mus. 23:61. 1873.

ON SMILACEAE: I.

Smilax rotundifolia Seaford, July 9, 1907, (1651); Lewes, Aug. 14, 1907; June 6, 1908, (2089); Townsend, June 11, 1890; A. Commons (1437); Newark, July 1891, A. Commons (Distributed in E. & E. N. A. Fungi 2708).

ON CYPERACEAE: II, III.

Carex comosa Boott, Lewes, Aug. 14, 1907, II, (1686), Nov. 16, 1907, III, (1853).

As noted above, on Aug. 14, 1907, the writer collected the uredo stage of a rust on Carex comosa at Lewes. Nearby was a vine of *Smilax rotundifolia* bearing aecia of *Aecidium macrosporum* Pk. *Aecidium Nesaeae* Ger. on *Decodon verticillata* was also collected at Lewes in the immediate vicinity of the rust on *Carex comosa.*

The material collected was sent to Dr. Arthur, who stated that the form on *Carex comosa* probably represented an undescribed species. A trip to the same vicinity was made at Dr. Arthur's request in November 1907 for the purpose of collecting this and other forms for culture work. Telia were collected on *Carex comosa* at that time, showing the form to be a Puccinia. The following spring Dr. Arthur (Mycol. 1:243. 1909) sowed this on various hosts, including *Smilax hispida* and the typical aecia of *Aecidium macrosporum* Pk. were produced.

69. PUCCINIA MALVACEARUM Bert. Gay's Hist. de Chile 8:43. 1852.

ON MALVACEAE:

Althaea rosea Cav., Newark, Oct. 16, 1909, J. Taubenhaus.

Malva rotundifolia L., Newark, May 24, 1913, Julia Clark, May 25, 1916, C. O. Houghton.

70. PUCCINIA MARYLANDICA Lindr. Medd. f. Stockh. Hogsk. Bot. Inst. 4:(2). 1901.

ON AMMIACEAE:

Sanicula canadensis L., Collins Beach, Oct. 1, 1907, (1815).

71. PUCCINIA MENTHAE Pers. Syn. Fung. 227. 1801.

ON LABIATAE:

Koellia mutica (Michx.) Britt., Clayton, July 24, 1907, (1709).

Monarda punctata L., Seaford, July 9, 1907.

72. Puccinia minutissima Arth. Bull. Torrey Club 34:587. 1907.

Aecidium Nesaeae Ger. Bull. Torrey Club 4:47. 1873. (Not *P. Nesaeae* E. & E. 1895.)

On Lythraceae: I.

Decodon verticillata (L.) Ellis, Seaford, July 9, 1907, (2256); Lewes, Aug. 14, 1907, (1690).

The Aecidium on Decodon was shown by Arthur in 1914 (Mycol. 7:86. 1915) to be the aecial stage of *P. minutissima.* Typical aecia were developed on Decodon, following inoculation with telial material on *Carex filiformis* from Ontario. The telial stage has not been found in Delaware and has apparently been collected but rarely. Species referred here in the Arthur herbarium occur on *C. teretiuscula, C. filiformis* and *C. aquatilis.*

73. Puccinia Nesaeae Ell. & Ev. Bull. Torrey Club 22:363. 1895. (Not *Aecidium Nesaeae* Ger. 1873.)

Aecidium Ludwigiae E. & E. Proc. Phil. Acad. 1893:155. 1893.

Puccinia Ludwigiae Holw. N. A. Ured. 1^3:72. 1907. (Not *P. Ludwigiae* Tepper 1890.)

Allodus Ludwigiae Orton, Mem. N. Y. Bot. Gard. 6:189. 1916.

On Onagraceae: I.

Ludwigia sphaerocarpa Ell., Ellendale, Sept. 1, 1892, A. Commons, (1983).

This collection is the type of *Aecidium Ludwigiae* E. & E. The name here used for this species was applied by Ellis and Everhart to a rust thought to be on Necium (Decodon). The host has been shown by Holway (l. c.) to be *Ludwigia polycarpa.* The name has frequently been misapplied to *Aecidium Nesaeae* Ger. on Necium which has been shown by Arthur (Mycol. 7:86. 1915) to be the aecial stage of *P. minutissima* (c. f. 67).

The rust is evidently an opsis form. Telia have been rarely collected, occurring in the Arthur herbarium only on *L. polycarpa* from Iowa and on *L. virgata* from Florida.

74. Puccinia nolitangeris Corda, Icones 4:16. 1840.

Puccinia argentata Wint. Rabh. Krypt. Fl. 1^2:194. 1881.

On Balsaminaceae: III.

Impatiens biflora Wald., Newark, Sept. 7, 1905; Sept. 15, 1906; Sept. 1907; (1552, 1535, 2005).

Bubak (Cent. Bakt. 10^2:574. 1903) has shown by cultures that the European *P. argentata* has its aecial stage on *Adoxa moschatellina*. Arthur in 1910 (Mycol. 4:20. 1912) successfully infected *Impatiens aurea* by sowing with aeciospores from *Adoxa moschatellina* collected in Iowa, thus proving the American and European rusts are the same.

75. PUCCINIA OBTECTA Pk. Bull. Buffalo Soc. Nat. Hist. 1:66. 1873.

Aecidium compositarum Bidentis Burrill; DeToni, in Sacc. Syll. Fung. 7:799. 1888.

ON CYPERACEAE:

Scirpus fluviatilis (Torr.) A. Gray? Wilmington, Nov. 5, 1885, A. Commons (1076).

Scirpus americanus Pers., Wilmington, Oct. 11, 1889, A. Commons (1026).

Arthur in 1907 (Jour. Myc. 14:20. 1908) has shown that *P. obtecta* Pk. has its aecial stage on Bidens. Successful sowings of teliospores from *A. americanus* collected in Indiana were made on *B. frondosa* and *B. comata*.

76. PUCCINIA ORBICULA Pk. & Curt. Ann. Rep. N. Y. State Mus. 30:53. 1879.

ON CICHORIACEAE:

Nabalus sp., Newark, 1907, M. T. Cook.

77. PUCCINIA PAMMELII (Trel.) Arth. Jour. Myc. 11:56. 1905.

Puccinia Panici Diet. Erythea 3:80. 1895.

Aecidium Pammelii Trel. Trans. Wis. Acad. Sci. 6:136. 1885.

ON POACEAE:

Panicum virgatum L., Selbyville, Oct. 4, 1907, (1789).

Stuart (Proc. Ind. Acad. Sci. 1901:284. 1902) shows by cultures that *Aecidium Pammelii* on *Euphorbia corollata* is the aecial stage of *P. panici*. These results were confirmed by Arthur in 1904 and 1905 (Jour. Myc. 11:56. 1905; 12:16. 1906) by sowing telial material on *P. virgatum* from Indiana, on *E. corollata* with resulting infection and development of aecia. In 1907 (Jour. Myc. 14:16. 1908) successful infection on *E. maculata* was obtained following sowings of teliospores from the same host collected in Nebraska. At the same time negative results were obtained on *E. corollata*. These results indicate the presence of physiological races in this species.

78. PUCCINIA PIMPINELLAE (Strauss) Mart. Fl. Mosq. Ed. II:226. 1817.

Uredo Pimpinellae Strauss, Wettst. Ann. 2:102. 1810.

Aecidium Osmorrhizae Pk. Ann. Rep. N. Y. State Mus. 24:92. 1872.

Puccinia Osmorrhizae C. & P.; Peck in Ann. Rep. N. Y. State Mus. 29:73. 1878.

ON AMMIACEAE:

Washingtonia brevistylis DC., Newark, May 2, 1907, I (1575), May 29, 1907, III, (1659).

79. PUCCINIA POCULIFORMIS (Jacq.) Wettst. Verhl. Zool.-Bot. Ges. Wien 35:544. 1885.

Lycoperdon poculiforme Jacq. Coll. Austr. 1:122. 1786.

Aecidium Berberidis Pers. in J. F. Gmel Syst. Nat. 2:1473. 1791.

Puccinia graminis Pers. Neues Mag. Bot. 1:119. 1794.

Puccinia Phlei-pratensis Erikss. & Henn. Zeit. f. Pflanzenkr. 4:140. 1894.

ON POACEAE:

Agrostis alba L., Newark, Aug. 23, 1907, (1715, 1713).

Phleum pratense L., Newark, Aug. 23, 1907, (1720).

Triticum vulgare L., Newark, Aug. 23, 1907, (1721).

DeBary (Monatsber. K. Akad. d. Wiss. Berlin 25. 1865) was the first to show that the well known *Puccinia graminis* developed its aecial form on Berberis. In 1864 he first sowed telia from *Agropyron repens* and *Poa pratensis* on leaves of Berberis resulting in the development of pycnia and aecia. He later (1865) infected *Secale cereale* by sowing aeciospores from Berberis. This is the first record of the connection of two stages of an heteroecious rust by inoculation. Since DeBary's first publication of the life history of this species a large number of mycologists in all parts of the world have conducted culture work confirming DeBary's results and adding to our knowledge of the species. For a review of this work see Klebahn (Die Wirtswechs Rostpilze Berlin 205-235. 1904).

In America the most important work has been conducted by Carleton (Div. Veg. Phys. & Path. U. S. D. A. Bull. 16. 1899; Bur. Pl. Ind. U. S. D. A. Bull. 63. 1904); Arthur (Jour. Myc. 8:53. 1902; 11:57.

1905; 12:17. 1906; 13:198. 1907; 14:16. 1908; Mycol. 2:227. 1910; 4:18. 1912); Freeman & Johnson (Bur. Pl. Ind. U. S. D. A. Bull. 216. 1911); Stakman (Minn. Exp. Sta. Bull. 138. 1914; Jour. Agr. Research 4:193-199. 1915); Stakman and Piemeisel (Jour. Agr. Research 6:813-816. 1916; 10:429-495. 1917).

80. PUCCINIA PODOPHYLLI Schw. Schrift. Nat. Ges. Leipzig 1:72. 1822.

ON BERBERIDACEAE:

Podophyllum peltatum L., Newark, May 1890, F. D. Chester, May 15, 1906, I, (1621), June 19, 1907, III, (1660); Hockessin, May 5, 1913; C. O. Houghton.

81. PUCCINIA POLYGONI-AMPHIBII Pers. Syn. Meth. Fungi 227. 1801.

Aecidium Geranii-maculati Schw. Schr. Nat. Ges. Leipzig 1:67. 1822.

Aecidium Sanguinolentum Lindr. Eot. Nat. 1900:241. 1900.

ON GERANIACEAE: I.

Geranium maculatum L., Wilmington, June 29, 1893, A. Commons (2099).

ON POLYGONACEAE: II, III.

Persicaria muhlenbergii (S. Wats.) Small (*Polygonum emersum* (Michx.) Britton), Wilmington, Aug. 17, 1886, A. Commons (297).

Persicaria pennsylvanicum (L.) Small (*Polygonum pennsylvanicum* L.), Newark, Sept. 17, 1890, F. D. Chester.

Dr. Tranzschel first showed (Centr. f. Bakt. 11^2:106. 1903) that this species on Polygonum was connected with *Aecidium Sanguinolentum* on Geranium sp. These results were confirmed in America by Arthur (Jour. Myc. 11:59. 1905) who used aeciospores from *Geranium maculatum* to inoculate *Polygonum emersum.* Uredinia and telia developed from this culture. In 1905 (Jour. Myc. 12:18. 1906) these results were confirmed by successfully sowing teliospores from *Polygonum emersum* on *Geranium maculatum* resulting in the typical aecia of *A. Sanguinolentum.* These results prove that the European and American rusts referred to this species are identical.

82. PUCCINIA POLYGONI-CONVOLVULI Hedw. f., Poiret. Encycl. Meth. Bot. 8:251. 1808.

Puccinia Polygoni A. & S. Consp. Fung. 132. 1805. (Not *P. Polygoni* Pers. 1794.)

ON POLYGONACEAE:

Polygonum Convolvulus L., Lewes, Aug. 14, 1907, II, (1692).

83. PUCCINIA PUSTULATUM (Curtis) Arth. Jour. Myc. 10:18. 1904.

Aecidium pustulatum Curtis; Peck, Ann. Rep. N. Y. State Mus. 23:60. 1873.

ON POACEAE:

Schizachyrium scoparium (Michx.) Nash (*Andropogon scoparius* Michx.), Seaford, Nov. 15, 1907, (1760).

This species of Andropogon rust is difficult to separate from *P. Andropogonis* Schw. In the latter, however, the uredospore markings are finely verrucose-echinulate with the pores 3-4 scattered (rarely appearing equatorial) while in the form here considered the uredospore markings are of the echinulate type and the pores 4-6 scattered.

The life history of this heteroecious rust was first determined by Arthur in 1903 (Jour. Myc. 10:17. 1904). He sowed germinating teliospores from *Andropogon furcatus* and *A. scoparius* collected in Indiana on *Comandra umbellata* and obtained the development of pycnia and aecia of *Aecidium pustulatum*. These experiments were successfully verified in 1905 and 1910 (Jour. Myc. 12:16. 1906; Mycol. 4:17. 1912) using telial material on *A. furcatus* from Indiana and Colorado.

84. PUCCINIA RECEDENS Syd. Monog. Ured. 1:146. 1902.

ON CARDUACEAE:

Senecio aureus L., Naaman's Creek, July 28, 1893, A. Commons (2129).

This species has previously been confused with *P. Asteris* Duby.

It is a micro-Puccinia common on *Senecio aureus* in the northeastern United States. It is known on other hosts from the Atlantic to the Pacific in the more northern states.

85. PUCCINIA RHAMNI (Pers.) Wettst. Verhl. Zool-Bot. Ges. Wein. 35:545. 1885.

Aecidium Rhamni Pers. in Gmel. Syst. Nat. 2:1472. 1791.

Puccinia coronata Corda, Icones 1:6. 1837.

On Poaceae:

Avena sativa L., Newark, July 17, 1903, C. O. Smith; Clayton, July 24, 1907, (1708).

This species is the common coronate spored rust and occurs throughout the United States on cultivated oats and on a great variety of native grasses. DeBary (Monat. Akad. Wiss. 211. 1866.) was the first to conduct culture experiments indicating the genetic connection with aecia on Frangula and Rhamnus in Europe. Since that time many European authors have conducted culture experiments, a summary of which has been made by Klebahn (Wirtw. Rostp. 254-262. 1904).

In America this species has been studied by Carleton (Div. Veg. Phys. & Path. 16:48. 1899), who obtained uredinia on cultivated oats, *Arrhenatherum elatius* and *Phalaris caroliniana* by sowing aeciospores from *Rhamnus lanceolata.* Carleton also carried out extensive cross inoculations between oats and many native grasses. (See also Bur. Pl. Ind. Bull. 63:15. 1904.)

At about the same time Arthur (Bull. Lab. Nat. Hist. State Univ. Iowa 4:398. 1898) obtained infection on oats with aeciospores from *R. lanceolata.* In 1904 the same author (Jour. Myc. 11:58. 1905) successfully confirmed the results of European and other investigators by sowing aeciospores from *Rhamnus cathartica, R. caroliniana, R. lanceolata* on *Avena sativa* resulting in the production of urediniospores in all cases. In 1910 the same author (Mycol. 4:18. 1912) successfully infected *Rhamnus cathartica* by sowing teliospores from *Calamagrostis canadensis* from Nova Scotia.

86. Puccinia rubella (Pers.) Arth. Bot. Gaz. 34:15. 1902.

Aecidium rubellum Pers. in Gmel. Syst. Nat. 2:1473. 1791.

Uredo Phragmites Schum. Enum. Pl. Saell. 2:231. 1803.

Puccinia Phragmites Koern. Hedwigia 15:179. 1876.

On Poaceae:

Phragmites Phragmites (L.) Karst., Wilmington, Nov. 1, 1893, A. Commons (2364).

Winter (Hedwigia 14:115. 1875) was the first to show the relation between *Puccinia Phragmites* and *Aecidium rubellum.* He successfully infected *Rumex hydrolapathum* with sporidia from Phragmites. He also infected the latter host, using aeciospores. These results have been

confirmed by several European investigators. The summary of their results will be found in Klebahn (Die Wirtsw. Rostp. 283. 1904).

Arthur in 1899 (Bot. Gaz. 29:269. 1900) produced aecia on *Rumex crispus* and *R. obtusifolius* with sowings of teliospores from *P. Phragmites*. These results have been repeatedly confirmed by the same author and reported in Jour. Myc. 9:220. 1903; 14:15. 1908; and Mycol. 2:225. 1910; 4:54. 1912.

Bates (Jour. Myc. 9:219. 1903) made some interesting field cultures and observations on the natural occurrence of the aecial stage on Rheum and Rumex (3 species) lending confirmatory evidence to the results of previous investigators.

87. PUCCINIA SAMBUCI (Schw.) Arth. Bot. Gaz. 35:15. 1903.

Aecidium Sambuci Schw. Schr. Nat. Ges. Leipzig 1:67. 1822.

Puccinia Bolleyana Sacc. Am. Microsc. Jour. 169. 1889.

Puccinia Atkinsoniana Diet. in Atk. Bull. Cornell Univ. 3:19. 1897.

Puccinia Thompsonii Hume, Bot. Gaz. 29:353. 1900.

ON CAPRIFOLIACEAE: I.

Sambucus canadensis L., Seaford, July 9, 1907, (1650), April 23, 1908, (2022).

Sambucus pubens Michx., Newark, June 9, 1907, (1665).

ON CYPERACEAE: II, III.

Carex bullata Schk., Seaford, June 4, 1908, (2083).

Carex lurida Wahl., Newark, Aug. and Sept., 1907, (1719, 1819); Felton, Sept. 5, 1907, (1738); Collins Beach, Oct. 1, 1907, (1788); Seaford, Nov. 14, 1907, (1767, 1858); June 5, 1908, (2082).

Arthur in 1901 conducted culture experiments (Jour. Myc. 8:55. 1902) proving that *Aecidium Sambuci* on *Sambucus canadensis* was specifically connected with *Puccinia Bolleyana* on *Carex trichocarpa*. In 1902 further experiments were conducted (Bot. Gaz. 35:14. 1903) confirming the above results and showing that *Puccinia Atkinsoniana* on *Carex lurida* is also a synonym and has its aecial stage on Sambucus. See also the results of culture work in 1904 (Jour. Myc. 11:58. 1905) and 1905 (Jour. Myc. 12:14. 1906) and 1906 (Jour. Myc. 13:195. 1907) in which *Carex lupulina* and *C. Frankii* are definitely proven to bear telia of *P. Sambuci*. The results of 1902 were confirmed in 1908 (Mycol. 1:233.

1909). Kellerman (Jour. Myc. 9:7. 1903) confirmed Arthur's results as to the connection of *Aecidium Sambuci* with *P. Atkinsoniana* on *Carex lurida* and with *P. Bolleyana* on *C. trichocarpa*.

88. PUCCINIA SMILACIS Schw. Schr. Nat. Ges. Leipzig 1:72. 1822.
Aecidium Smilacis Schw. Schr. Nat. Ges. Leipzig 1:69. 1822.
ON SMILACEAE:
Smilax glauca Walt., Selbyville, Oct. 4, 1907, (1752).
Smilax rotundifolia L., Newark, October 1907, (2007); Collins Beach, Oct. 1, 1907, (1816); Selbyville, Oct. 4, 1907, (1754).

This is an autoecious long cycle rust common throughout the eastern United States. No aecial collections have been made in Delaware. The aecia may be distinguished from the aecia of *Puccinia macrospora* (Pk.) Arth., which occur on Smilax in the same range, by the size of the aeciospores. In *P. Smilacis* the aeciospores are 17-22x20-30μ with the walls 1-1.5μ while the aecispores of *P. macrospora* measure 32-42x37-51μ with thick walls 1.5-2.5μ, thickened above to 5-10μ.

89. PUCCINIA SORGHI Schw. Trans. Am. Phil. Soc. II. 4:295. 1832.
Puccinia Maydis Bereng. Atti Sci. Hal. 6:475. 1844.
Aecidium Oxalidis Thüm. Flora 59:425. 1876.
ON POACEAE:
Zea Mays L., Faulkland, Sept. 8, 1885, A. Commons (210); Newark, Sept. 17, 1890, F. D. Chester; Sept. 1907; Felton, Sept. 5, 1907, (1735).

The corn rust is very common in Delaware and has been repeatedly observed but apparently does little damage.

Arthur in 1904 (Bot. Gaz. 38:64. 1904; Jour. Myc. 11:65. 1905) shows that the corn rust has its aecial stage on Oxalis. These results were confirmed in 1905 by the same author (Jour. Myc. 12:17. 1906) who successfully infected corn with aeciospores from *Oxalis cymosa*.

90. PUCCINIA SUBNITENS Diet. Erythea 3:81. 1895.
ON CHENOPODIACEAE: I.
Atriplex hastata L., Lewes, April 1908, (2041), June 6, 1908, (2038).
ON CRUCIFEROUS SEEDLING: I.
Lewes, April 23, 1908, (2025).

On Polygonaceae: I.

Polygonum aviculare L., Lewes, April 25, 1908, (2020).

On Poaceae: II, III.

Distichlis spicata (L.) Greene, Lewes, Aug. 14, 1907, (1677), Nov. 16, 1907, (1854, 1855), April 25, 1908, (2021), June 6, 1908, (2039).

Arthur (Bot. Gaz. 35:19. 1903 first showed that the above species has its aecial form on Chenopodiaceae having produced aecia on *Chenopodium album* by sowings of teliospores from *Distichlis spicata.* In 1904 (Jour. Myc. 11:54. 1905) he records successful infection results on *Chenopodium album, Cleome spinosa, Lepidium apetalum, L. virginicum, Sophia incisa, Erysimum asperum,* from sowings of teliospores from *Distichlis spicata.* This is remarkable since the above hosts represent three distinct families of flowering plants.

In 1905 (Jour. Myc. 12:16. 1906) *Bursa Bursa pastoris* is added to the above list, since aecia were produced following sowings of teliospores from *Distichlis spicata.* Further results are recorded by the same author in 1906 (Jour. Myc. 13:197. 1907) and in 1907 (Jour. Myc. 14:15. 1908).

In 1908 Arthur records successful infection on *Chenopodium album* resulting from sowings of teliospores from *Distichlis spicata* collected at Lewes, Del., and sent to Dr. Arthur by the writer (Mycol. 1:234. 1909). Cultures from Nebraska made in the same year were successful on *C. album.* Material from Nevada successfully infected *C. album, Atriplex hastata,* and *Sarcobatus vermiculatus.*

Further culture work with this species is recorded by Arthur in Mycol. 2:225. 1910; 4:18. 1912. (See also Bethel, Phytopath. 7:92-94. 1917.)

91. Puccinia Taraxaci (Rebent.) Plowr. Brit. Ured. and Ust. 186. 1889.

Puccinia Phaseoli var. *Taraxaci* Rebent. Fl. Neomarch 256. 1804.

On Cichoriaceae:

Taraxacum Taraxacum (L.) Karst.,—Newark, July 1907, (1671).

This is doubtless a brachy-form though no pycnia have yet been demonstrated to accompany the primary uredinia. Cultures will be

necessary to determine its life history with certainty. It seems probable that the uredinia are able to carry the fungus over the winter.

92. PUCCINIA TRITICINA Erikss. Ann. Sci. Nat. VIII, 9:270. 1899.

ON POACEAE:

Triticum vulgare L., Newark, July 2, 1907, (1882), June 21, 1907, (1662).

This is the common leaf rust of wheat found in all parts of the United States as well as in most sections of the world where wheat is cultivated. The life history is unknown. It is a sub-epidermal form and is morphologically very similar to leaf rusts on wild grasses commonly referred to *P. tomipara* and *P. Agropyri* (*P. clematidis* (DC.) Lagerh.), having aecia on Thalictrum, Clematis and other Ranunculaceous hosts.

93. PUCCINIA URTICATA (Lk.) Kern, Mycologia 9:214. 1917.

Aecidium Urticae Schum. Enum. Pl. Saell. 2:222. 1803.

Caeoma urticatum Link, in Willd. Sp. Pl. 6^2:62. 1825.

Puccinia Urticae Lagerh. Mitt. Bad. Ver. 2:72. 1889. (Not *P. Urticae* Barcl. 1887.)

ON CYPERACEAE: II, III.

Carex stricta Lam., Seaford, April 23, 1908, (2029).

Magnus in 1872 (Vehr. Bot. Ver. Prov. Brandbg. 14:1872.) first showed that *Aecidium Urticae* on *Urtica dioica* was the aecial stage of *P. Caricis* (Schum.) Rebent. on *Carex hirta*. Many other European investigators have repeated this work with additional hosts, including Schroeter, Cornu, Plowright, Ed. Fischer and Klebahn. A general review is given by Klebahn (Wirtsw. Rostp. 293. 1904).

In America Arthur (Bot. Gaz. 29:270. 1900) was the first to conduct successful cultures. He obtained the development of uredinia on *Carex stricta* by inoculating with spores of *Aecidium Urticae*.

Later cultures (Jour. Myc. 8:52. 1902; Bot. Gaz. 35:16. 1903) showed that aeciospores developed on Urtica gracilis following sowings of teliospores from *Carex stricta* collected in Nebraska and *C. riparia* from Iowa. In 1905 (Jour. Myc. 12:15. 1906) teliospores on *C. stipata* from Indiana and from *C. aquatilis* collected in Colorado, were used in successful cultures on *U. gracilis*. In 1907 (Jour. Myc. 14:14. 1908) Arthur again conducted successful sowings of teliospores from Indiana material on *C. stipata* and from Nebraska material on *C. riparia*. In

1909 the same author (Mycol. 2:223. 1910) used teliospores from *C. aristata* from North Dakota to successfully infect *U. gracilis* with production of aecia. In 1910 (Mycol. 4:17. 1912) the results of 1909 were repeated and successful sowings on *U. gracilis* were again made by using Indiana material to infect *U. gracilis.*

Kellerman in 1902 (Jour. Myc. 9:9. 1903) was also successful in obtaining infection on *U. gracilis* by using telial material on *C. riparia* and *C. stricta* from Ohio.

94. PUCCINIA VIOLAE (Schum.) DC. Fl. Fr. 6:62. 1815.

Aecidium Violae Schum. Enum. Pl. Saell. 2:224. 1803.

ON VIOLACEAE:

Viola affinis LeConte, Newark, May 15, 1906, I, (1622).

Viola Labradorica Schw. (?), Faulkland, Aug. 1, 1884, II, III, A. Commons, (193).

Viola lanceolata L., Selbyville, Oct. 4, 1907. (1938).

95. PUCCINIA WINDSORIAE Schw. Trans. Am. Phil. Soc. II 4:295. 1832.

Aecidium Pteleae Berk. & Curtis; Berkeley, Grevillea 3:60. 1874.

ON POACEAE: II, III.

Tricuspis seslerioides (Michx.) Torr., Lewes, Nov. 16, 1907, (1852); Newark, Oct. 16, 1907, (1834).

This species has been shown to be connected with *Aecidium Pteleae* on *Ptelea trifoliata* by Arthur in 1899 (Bot. Gaz. 29:273. 1900). He succeeded in obtaining the development of typical uredinia of this species on *Tricuspis seslerioides* by inoculating with aeciospores of *Aecidium Pteleae* from Indiana. These results were confirmed in 1902 (Bot. Gaz. 35:16. 1903) and again in 1904 (Jour. Myc. 11:56. 1905).

96. PUCCINIA XANTHII Schw. Schr. Nat. Ges. Leipzig 1:73. 1822.

ON AMBROSIACEAE:

Ambrosia trifida Mill., Newark, Sept. 15, 1905, (1556); July 26, 1906, (1616); Aug. 23, 1907, (1723).

Xanthium sp., Newark, Sept. 15, 1905, (1540); Lewes, Aug. 14, 1907, (1691).

This common species is a lepto-form possessing telia only in the life history.

Carleton (Bur. Pl. Ind. U. S. D. A. Bull. 63:26. 1904) in 1897 and 1898 conducted culture experiments showing that this species is auto-

ecious. He repeatedly infected Xanthium seedlings by inoculating with teliospores from same host but was unable to infect *Ambrosia trifida.* He believes this species to be distinct from the form on *Ambrosia trifida.*

In 1905 and 1906 Arthur (Jour. Myc. 12:20. 1906; 13:198. 1907) confirmed Carleton's work. He also failed to infect *Ambrosia trifida* with spores from Xanthium. No pycnia have been found in herbarium specimens nor did they develop in the cultures recorded above.

It is evident from these culture experiments that we have here a rust, while morphologically indistinguishable on the two host genera, yet exists in two independent races.

97. RAVENELIA EPIPHYLLA (Schw.) Dietel, Hedwigia 33:27. 1894.

Sphaeria epiphylla Schw. Schr. Nat. Ges. Leipzig 1:40. 1822.

ON FABACEAE:

Cracca virginiana L., Townsend, June 11, 1890, A. Commons (1438).

98. TRANZSCHELIA PUNCTATA (Pers.) Arth. Result Sci. Congr. Bot. Vienna 340. 1906.

Aecidium punctatum Pers. Ann. Bot. Usteri 20:135. 1796.

Puccinia Pruni-spinosae Pers. Syn. Fung. 226. 1801.

ON RANUNCULACEAE: I.

Anemone quinquefolia L., Newark, May 8, 1897, F. D. Chester, May 10, 1907, (1656).

Hepatica Hepatica (L.) Karst, Faulkland, May 3, 1884, A. Commons, Newark, May 22, 1907, (1566), May 1908, (2254).

ON AMYGDALACEAE: II, III.

Prunus serotina Ehrh., Greenbank, Aug. 24, 1886, A. Commons (26).

Dr. Tranzschel in 1904 (Trans. Mus. Bot. Acad. St. Petersb. 11:67-69. 1905) first showed that *Aecidium punctatum* on Anemone was the aecial stage of *P. Pruni-spinosae.* He succeeded in obtaining the characteristic uredinia of this species on *Amygdalus communis, Prunus spinosa* and *P. divaricata* following sowings with aeciospores from *Anemone coronaria.* Aecia on *Anemone ranunculoides* were also used to infect *Prunus spinosa* with similar results.

In America Arthur in 1905 (Jour. Myc. 12:19. 1906) showed that this species has its aecia on *Hepatica acutiloba* (*Aecidium Hepaticum*

Schw.) having successfully infected *Prunus serotina* with aeciospores from that host. These results were confirmed in 1906 (Jour. Myc. 13:199. 1907); a successful infection resulting in uredinia having been obtained on *P. serotina* and *P. pumila* following inoculation with aecia on Hepatica. Failure to obtain infection on *P. americana, P. cerasus* and *Amygdalus Persica,* however, indicates that in America at least there are distinct races.

It is probable that the uredinial spores are able to carry this species over the winter in some localities.

The aecial stage is perennial and the affected leaves are characteristically modified. On Hepatica the leaves stand upright and are much reduced in size and greatly thickened.

99. UROMYCES APPENDICULATUS (Pers.) Fries, Summa Veg. Scand. 514. 1849.

Uredo appendiculata Pers. Ann. Bot. Usteri 15:16. 1795.

Uromyces Phaseoli Wint. in Rab. Krypt. Fl. 1^1:157. 1881.

Nigredo appendiculata Arth. Result. Sci. Congr. Bot. Vienna 343. 1906.

ON FABACEAE:

Phaseolus vulgaris L., Lewes, Aug. 14, 1907, (1684); Newark, September 1905, (1632); Selbyville, Oct. 4, 1907, (1981).

Strophostyles helvola (L.) Britt., Lewes, Aug. 14, 1907, (1682); Felton, Sept. 5, 1907, (1736).

Strophostyles umbellata (Muhl.) Britt., Selbyville, October 4, 1907, (1987); Wilmington, Oct. 11, 1907, (1932).

That the above is an autoecious form was shown by Arthur in 1903 (Jour. Myc. 10:14. 1904). He cultured the form on *Strophostyles helvola.* Pycnia and aecia followed inoculation with over-wintered teliospores on the same host.

100. UROMYCES CALADII (Schw.) Farl. Ellis, N. A. Fungi 232. 1879.

Aecidium Caladii Schw. Schr. Nat. Ges. Leipzig 1:69. 1822.

Uromyces Peltandrae Howe, Bull. Torrey Club 5:3. 1874.

Nigredo Caladii Arth. Result. Sci. Congr. Bot. Vienna 343. 1906.

ON ARACEAE:

Arisaema dracontium Schott., Faulkland, June 4, 1885, A. Commons.

Arisaema triphyllum (L.) Schott., Newark, May 1892, I, F. D. Chester, May 15, 1906, (1619); Faulkland, July 18, 1885, III, A. Commons.

Peltandra virginica (L.) Kunth, Symrna, June 9, 1894, A. Commons; Seaford, July 9, 1907, (1672, 1864); Lewes, Aug. 14, 1907, (2261); Wilmington, Oct. 11, 1907, (1931).

101. UROMYCES CARYOPHYLLINUS (Schrank.) Wint. in Rab. Krypt. Fl. 1^1:149. 1881.

Lycoperdon caryophyllinum Schrank. Baier. Fl. 2:668. 1789.

ON CARYOPHYLLACEAE:

Dianthus caryophyllus L., Wilmington, Jan. 1909, C. O. Houghton.

102. UROMYCES ERAGROSTIDIS Tracy, Jour. Myc. 7:281. 1893.

Nigredo Eragrostidis Arth. Result. Sci. Congr. Bot. Vienna 343. 1906.

ON POACEAE:

Eragrostis pectinacea (Michx.) Steud., Selbyville, Oct. 4, 1907, (1792).

103. UROMYCES FALLENS (Des.) Kern, Phytopathology 1:6. 1911.

Uredo fallens Desmaz. Pl. Crypt. 1325. 1843.

Nigredo fallens Arth. N. Am. Flora 7^3:254. 1912.

ON FABACEAE:

Trifolium incarnatum L., Newark, spring 1905, C. O. Smith.

Trifolium pratense L., Newark, October 1888, F. D. Chester; Nov. 10, 1910, C. O. Houghton; Seaford, July 9, 1907, (1654); Clayton, July 24, 1907, (1710); Selbyville, Oct. 4, 1907 (1992).

The rust on red clover is widely distributed in the state and probably occurs wherever this host is cultivated. It is, however, rare on the crimson clover; only one other collection in America is known to the writer, and that was collected in South Dakota. This species is readily separated from the only other long cycled Uromyces on Trifolium occurring in North America by the uredinial pore characters. In the species under discussion the pores are 4-6, scattered, while in *U. Trifolii* the pores are 3-4 in an equatorial zone.

104. UROMYCES GRAMINICOLA Burrill, Bot. Gaz. 9:188. 1884.

Uromyces Panici Tracy, Jour. Myc. 7:281. 1893.

Nigredo graminicola Arth. Result Sci. Congr. Bot. Vienna 343. 1906.

ON POACEAE:

Panicum virgatum L., Collins Beach, Oct. 1, 1907, (1779); Selbyville, Oct. 4, 1907, (1790).

This species is inseparable morphologically from *Puccinia Panici* Diet. except in the number of cells in the teliospore. The Puccinia has been studied culturally by Stuart (Proc. Ind. Acad. Sci. 1901:284. 1902) and Arthur (Jour. Myc. 11:56. 1905; 12:16. 1906; 14:16. 1908) and shown to be connected genetically with *Aecidium Pammelii* Trel. on *Euphorbia corollata* in Indiana and *E. marginata* in Nebraska. Aecia on various Euphorbiaceous hosts have also been referred to that species on morphological grounds.

While no cultures of the Uromyces have been successfully carried out, it is probable that the aecial stage will be found on some member of the Euphorbiaceae. The field evidence at present available suggests that *A. Stellingiae* Tracy & Earle, which occurs on various species of Stellingia and Sebastina in the south and southwest is a very probable aecial connection. This aecidium is morphologically indistinguishable from *A. Pammelii* and it is possible that some of the forms now referred to that species will be found to belong here.

105. UROMYCES HALSTEDII DeToni in Sacc. Syll. Fung. 7:557. 1888.

Uromyces digitatus Halsted, Jour. Myc. 3:138. 1887. (Not *U. digitatus* Wint. 1886.)

Nigredo Halstedii Arth. N. Am. Flora 7^3:226. 1912.

ON POACEAE:

Homalocenchrus oryzoides (L.) Poll. (*Leersia oryzoides* (L.) Sw.), Seaford, April 23, 1908, (2034).

The aecial stage of this rather rare grass rust is at present unknown. The telial stage is known to the writer on the above host otherwise only from Wisconsin and South Dakota.

106. UROMYCES HEDYSARI-PANICULATI (Schw.) Farl. Ell. N. A. Fungi 246. 1879.

Puccinia Hedysari-paniculati Schw. Schr. Nat. Ges. Leipzig 1:74. 1822.

Nigredo Hedysari-paniculati Arth. Result Sci. Congr. Bot. Vienna 343. 1906.

ON FABACEAE:

Meibomia Dillenii (Darl.) Kuntze, Faulkland, Aug. 24, 1886, A. Commons (319); Newark, Sept. 10, 1905, (1626); Aug. 23, 1907, (1726).

Meibomia laevigata (Nutt.) Kuntze, Selbyville, July 18, 1895, A. Commons (946).

Meibomia Marylandica (L.) Kuntze, Felton, Sept. 5, 1907, (1748); Selbyville, Oct. 4, 1907, (1986).

Meibomia obtusa (Muhl.) Vail, Felton, Sept. 5, 1907, (1747).

Meibomia paniculata (L.) Kuntze, Felton, Sept. 5, 1907, (1745); Selbyville, Oct. 4, 1907, (1985); Lewes, Aug. 14, 1907, (1200); Newark, Aug. 23, 1907, (1714).

Meibomia stricta (Pursh) Kuntze, Selbyville, Oct. 4, 1907, (1984).

107. UROMYCES HOUSTONIATUS (Schw.) J. Sheldon, Torreya 9:55. 1909.

Aecidium houstoniatum Schw. Tran. Am. Phil. Soc. II. 4:309. 1832.

Nigredo houstoniata Sheldon, Torreya 9:55. 1909.

ON RUBIACEAE:

Houstonia coerulea L., Newark, May 1908, I, (2267); Wilmington, May 31, 1914, C. O. Houghton.

Sheldon (l. c.) was the first to prove by culture experiments that *Aecidium houstoniatum* Schw. on *Houstonia coerulea* was genetically connected with a telial form occurring on *Sisyrinchium gramineum*. Arthur (Mycologia 1:237. 1908) confirms Sheldon's work using living plants of *Houstonia coerulea* bearing aecia collected by the writer at the above noted locality near Newark, and sent to Dr. Arthur at his request for that purpose. A search was made for the telial stage in the field but without success. The telia have been collected only in Maine and West Virginia.

108. UROMYCES HOWEI Pk. Ann. Rep. N. Y. State Mus. 30:75. 1879.

ON ASCLEPIADACEAE:

Asclepias pulchra Shrk., Newark, Sept. 14, 1905, (1631).

Asclepias Syriaca L., Wilmington, August 1894, A. Commons (issued as E. & E. Fungi Columb. 648); Newark, Sept. 7, 1905, (1551); Wilmington, Oct. 11, 1907, (1930).

The life history of this common species is in doubt. It seems probable that it is autoecious though no aecia have ever been collected. Attempts to culture this species have been unsuccessful owing to a failure of the teliospores to germinate. In future study of this species it should be borne in mind that the species may be heteroecious or a brachy-form.

109. UROMYCES HYPERICI-FRONDOSI (Schw.) Arth. Bull. Minn. Acad. Nat. Sci. 2^2:15. 1883.

Aecidium Hyperici-frondosi Schw. Schr. Nat. Ges. Leipzig 1:68. 1822.

Nigredo Hyperici-frondosi Arth. Result Sci. Congr. Bot. Vienna 344. 1906.

ON HYPERICACEAE:

Hypericum mutilum L., Felton, Sept. 5, 1907, (1751); Selbyville, Oct. 4, 1907, (1991).

Triandeum virginicum (L.) Raf., Selbyville, Oct. 4, 1907, (2247).

110. UROMYCES JUNCI-EFFUSI Sydow, Monog. Ured. 2:290. 1910.

Nigredo Junci-effusi Arth. N. Am. Flora 7^3:239. 1912.

ON JUNCACEAE:

Juncus effusus L., Newark, Oct. 14, 1905, (1537); Clayton, July 24, 1907, (1703); Collins Beach, Oct. 1, 1907, (1779).

This species is common throughout the eastern United States on this host and is separated from *U. Silphii* on Juncus by the presence of 3-4 equatorial germ pores in the uredospores. In the latter there are but 2 pores arranged slightly above the middle.

111. UROMYCES LESPEDEZAE-PROCUMBENTIS (Schw.) Curt. Cat. Pl. N. Car. 123. 1867.

Puccinia Lespedezae-procumbentis Schw. Schr. Nat. Ges. Leipzig 1:73. 1822.

Nigredo Lespedezae-procumbentis Arth. N. Am. Flora 7:247. 1912.

ON FABACEAE:

Lespedeza frutescens (L.) Britton, Felton, Sept. 5, 1907, III, (1749); Selbyville, Oct. 4, 1907, III, (1983); Newark, Sept. 11, 1905, III, (1625).

Lespedeza hirta (L.) Hornem., Clayton, July 24, 1907, I, (1705).
Lespedeza virginica (L.) Britt., Newark, Sept. 10, 1907, III, (1730); Selbyville, Oct. 4, 1907, (1988).

This species is very common and widely distributed east of the Rocky mountains on various species of Lespedeza and has been shown to be autoecious by Arthur (Jour. Myc. 10:14. 1904). The aecial form known as *A. leucostictum* having been produced by infecting *Lespedeza capitata* with teliospores from the same host.

112. UROMYCES MEDICAGINIS Pass. Thüm. Herb. Myc. Oecon. 156. 1874.
Nigredo Medicaginis Arth. N. Am. Flora 7:256. 1912.

ON FABACEAE:

Medicago lupulina L., Wilmington, June 22, 1889, A. Commons (920).

The aecia of this species in Europe have been shown by Schroeter (Krypt. Fl. Schl. 3[1]:306. 1887) and by Trebaux (Ann. Myc. 10:74. 1912) to occur on various species of Euphorbia.

No aecia in America have been found which can be referred to this species. There is, however, no evidence at present available for believing the American species different from the European.

113. UROMYCES PEDATATUS (Schw.) Sheldon, Torreya 10:90. 1910.
Caeoma pedatatum Schw. Trans. Am. Phil. Soc. II. 4:293. 1832.
Uromyces Andropogonis Tracy, Jour. Myc. 7:281. 1893.

ON VIOLACEAE: I.

Viola lanceolata L., Lewes, April 25, 1908, (2036).
Viola sagittata L., Newark, June 12, 1897, F. D. Chester; Porters, June 1908; Lewes, April 14, 1908.

ON POACEAE: II, III.

Andropogon glomeratus (Walt.) B. S. P., Selbyville, Oct. 4, 1907, (1795, 1805, 1796, 1797), (Barth. Fungi Columb. 3088); Lewes, Nov. 16, 1907, (1857).
Andropogon virginicus L., Newark, Sept. 10, 1907, III, (1732); Lewes, April 23, 1908, II, (2037), June 7, 1908, III, (2088).

Dr. J. L. Sheldon (Torreya 9:55. 1909) was the first to show that in West Virginia the aecial stage of this species on Andropogon occurred on Viola, having obtained successful infection resulting in aecia by using

teliospores from *Andropogon virginicus* L. Arthur in 1909 (Mycol. 2:229. 1910) confirmed the results of Sheldon by obtaining infection resulting in abundant pycnia on *Viola cucullata* following sowings of teliospores from *Andropogon virginicus* sent by Sheldon from West Virginia.

Long (Phytopath. 2:165. 1912) reports successful infection of *Viola primulifolia* and *V. cucullata* by inoculation with teliosporic material from the same telial host used by Sheldon and Arthur. Aeciospores from *V. primulifolia* were used to inoculate the telial host resulting in typical uredinia of *U. pedatatus*.

114. Uromyces perigynius Halsted, Jour. Myc. 5:11. 1889.

Uromyces caricina E. & E. Bull. Torrey Club 22:58. 1895.

Uromyces Solidagini-Caricis Arth. Jour. Myc. 10:16. 1904.

Nigredo perigynia Arth. Result Sci. Congr. Bot. Vienna 334. 1906.

On Cyperaceae:

Carex scoparia Schk., Newark, Sept. 10, 1907, (1731, 1734), April 5, 1908; Felton, Sept. 5, 1907, (1743); Collins Beach, Oct. 1, 1907, (1775).

Carex tribuloides Wahl., Collins Beach, Oct. 1, 1907, (1782); Felton, Sept. 5, 1907, (1739).

This species is correlated with a Puccinia occurring on Carex and Dulichium which has been referred to under various specific names. (See *P. asteratum.*) The species are morphologically indistinguishable except in the number of cells in the teliospore.

The Uromyces has been studied in culture by Arthur and Fraser. The first study leading to an understanding of the species was made by Arthur (Jour. Myc. 10:16. 1904) who used telial material on *Carex varia* from Indiana and obtained infection resulting in aecia on *Solidago canadensis, S. serotina, S. flexicaulis* and *S. caesia.* The results were confirmed in 1910 by the same author (Mycol. 4:21. 1912) when infection resulting in aecia was obtained on *S. rugosa* using telial material on *C. deflexa* collected in Nova Scotia and Maine. This species was, at this time, also shown to have aecia on Aster by successful sowings of teliospores from *Carex intumescens* collected in Nova Scotia on *A. paniculatus* and from *C. deflexa* from Maine on *A. ericoides.*

Fraser in 1911 (Mycol. 4:181. 1912) successfully infected *S.*

rugosa (?) and *S. bicolor* by sowing teliospores from *Carex deflexa* from Nova Scotia. Similar results were obtained on *Euthamia graminifolia* when infected with teliospores from *C. scoparia* and on Solidago sp. from *C. intumescens.*

Arthur in 1912 (Mycol. 7:75. 1915) reports infection of *Aster paniculatus* and *S. canadensis* following sowings of teliospores from *C. intumescens* collected in New York and in 1914 (Mycol. 7:83. 1915) on *A. Tweedyi* from *C. tribuloides* collected in Indiana.

The aecia obtained in these cultures are indistinguishable from the aecia resulting from sowings of the correlated Puccinia. Field collections of aecia on Aster, Solidago, etc., can be properly referred only when close observations of the source of infection are made.

115. UROMYCES PLUMBARIUS Peck, Bot. Gaz. 4:127. 1879.

Uromyces Oenotherae Burrill, Bot. Gaz. 9:187. 1884.

Nigredo plumbaria Arth. N. Am. Flora 7:262. 1912.

ON ONAGRACEAE: I.

Oenothera biennis L., Newark, May 1908, I (2266).

Oenothera laciniata Hill, Seaford, June 4, 1908, I (2044).

116. UROMYCES POLEMONII (Peck) Barth. N. Am. Ured. 597. 1913.

Aecidium Polemonii Peck, Bot. Gaz. 4:230. 1878.

Uromyces acuminatus Arth. Bull. Minn. Acad. Sci. p. 35. 1883.

Nigredo Polemonii Arth. N. Am. Flora 7^3:231. 1912.

ON POACEAE: II, III.

Spartina glabra alternifolia (Loisel) Merr., Lewes, Oct. 16, 1907, (1774, 1850).

When teliosporic material from *S. cynosuroides* collected in Nebraska was used by Arthur to inoculate *Steironema ciliata* (Jour. Myc. 12:25. 1906; 14:17. 1908) aecia developed. In 1909 Arthur (Mycol. 2:229. 1910) confirmed the results with *S. ciliata* and also records successful infection of *S. lanceolata.* In 1910 (Mycol. 4:29. 1912) the development of aecia was obtained on *Polemonium reptans* following sowings of teliospores from *S. cynosuroides* collected in North Dakota and Colorado.

Fraser in 1911 (Mycol. 4:186. 1912) obtained infection resulting in aecia on *Arenaria lateriflora* following sowings with teliosporic ma-

terial from *Spartina Michauxiana* and on *Spergula canadensis* from *Spartina glabra* var. *alternifolia* and on *Spergula canadensis* from *Spartina patens*.

In 1912 Arthur again conducted cultures (Mycol. 7:77. 1915) and obtained infection and development of aecia on *Collomia linearis* when telial material from Colorado was used.

From these successful results, taken together with the negative results recorded by the investigators mentioned, it would appear that well marked biological races of this species exist or that distinct species are here included.

Orton (Mycol. 4:202. 1912) pointed out that it is not possible to distinguish this species from *Puccinia Distichlidis* E. & E., the telial stage of which occurs on Spartina sp., except in the possession of one-celled teliospores. Arthur in 1915 (Mycol. 8:136. 1916) has shown that the aecial stage of the Puccinia develops on Steironema and is morphologically identical with *Aecidium Polemonii*, thus strengthening the morphological evidence of the relationship between the two forms.

117. UROMYCES POLYGONI (Pers.) Fuckl. Symb. Myc. 64. 1869.
Puccinia Polygoni Pers. Neues Mag. Bot. 1:119. 1794.
Nigredo Polygoni Arth. Result Sci. Congr. Bot. Vienna 344. 1906.
ON POLYGONACEAE:
Polygonum aviculare L., Newark, Aug. 17, 1907, III, (1712).
Polygonum erectum L., Newark, September 1888, F. D. Chester, June 21, 1907, II, (1668).

118. UROMYCES PONTEDERIAE W. Gerard, Bull. Torrey Club 6:31. 1875.
Nigredo Pontederiae Arth. N. Am. Flora 7^3:238. 1912.
ON PONTEDERIACEAE:
Pontederia cordata L., Milford, Sept. 1, 1892, A. Commons (1986).

This species is evidently rather rare, having been recorded in North America by Arthur (l. c.) in but four states on the Atlantic coast from New York to Florida and in Missouri. Only four other collections are known to the writer. It also occurs in South America. This species is assumed to be autoecious though no aecia have been found.

119. UROMYCES PROEMINENS (DC.) Pass. Rab. Fungi Eur. 1795. 1873.

Uredo proeminens DC. Fl. Fr. 2:235. 1805.

Uromyces Euphorbiae C. & P.; Peck, Ann. Rep. N. Y. State Mus. 25:90. 1873.

Nigredo proeminens Arth. N. Am. Flora 7^3:259. 1912.

ON EUPHORBIACEAE:

Euphorbia maculata L., Newark, September 1905, (1633), Lewes, Aug. 14, 1907, (1695), Selbyville, Oct. 4, 1907, (1980).

Euphorbia Preslii Guss., Newark, Sept. 14, 1907, III, (1630), Seaford, July 9, 1907, I, (1666); July 9, 1907, II, III, (1655), Selbyville, Oct. 4, 1907, (1994).

That this species is autoecious was first demonstrated by Arthur in 1899 (Bot. Gaz. 29:270. 1900) and later confirmed by the same author (Jour. Myc. 8:51. 1902; Bot. Gaz. 35:12. 1903). The results, however, indicate that well marked biological forms are present.

120. UROMYCES RHYNCOSPORAE Ellis, Jour. Myc. 7:274. 1893.

Nigredo Rhyncosporae Arth. Result Sci. Congr. Bot. Vienna 344. 1906.

ON CYPERACEAE: II, III.

Rynchospora axillaris (Lam.) Britton, Lewes, Aug. 14, 1907, (1687).

Rynchospora glomerata (L.) Vahl., Selbyville, Oct. 4, 1907, (1801, 1811); Seaford, Nov. 15, 1907, (1768, 1769), April 23, 1908, (2031); Lewes, Nov. 16, 1907, (1856).

All cultures so far attempted with this species have yielded negative results. It is very close morphologically to *Uromyces perigynius* which has been shown to have aecia on Aster and Solidago. In spite of the fact that attempts to infect these genera by Arthur (Mycol. 7:65. 1915) were unsuccessful, the writer is inclined to the view that it will ultimately be shown that this species has its aecia on Aster and Solidago.

121. UROMYCES SCIRPI (Cast.) Burrill, Par. Fungi Ill. 168. 1885.

Uredo Scirpi Cast. Cat. Pl. Mars. 214. 1845.

ON AMMIACEAE: I.

Hydrocotyle Canbeyi C. & R., Lewes, Aug. 14, 1907, I, (1688), June 6, 1908, (2090).

Sium cicutaefolium Gmel., Wilmington, July 11, 1890, 1, A. Commons (1483).

ON CYPERACEAE: II, III.

Scirpus americanus Pers., Lewes, Aug. 14, 1907, II, (1679, 1689), June 6, 1908, (2091); Selbyville, Oct. 4, 1907, (1806).

Scirpus fluviatilis (Torr.) A. Gray, Collins Beach, Oct. 1, 1907, III, (1787).

In Europe P. Dietel (Hedwigia 29:149. 1890) was the first to successfully connect this species with its aecial form. He showed by cultures that aecia are produced on *Sium latifolium* and *Hippurus vulgaris*. Plowright (Gard. Chron. III. 7:682. 1890) added *Glaux maritima* as an aecial host of this species. Bubak in Bohemia (Cent. Bakt. 9^2:926. 1902) discovered a form which only infected *Berula angustifolia*. Further cultures carried out by Klebahn (Jahr. Hamb. Wiss. Anst. 20:33. 1903) brought out new hosts and interesting biological relations.

In America Arthur in 1906, 1907 and 1908 (Jour. Myc. 13:199. 1907; 14:17. 1908; Mycol. 1:237. 1909) showed that in America *Cicuta maculata* was an aecial host. Fraser (Mycol. 4:178. 1912) confirmed Arthur's work using telia on *Scirpus campestris paludosus*.

The aecidium on *Hydrocotyle Canbeyi* is included here partly on morphological grounds and partly on field observations. As noted above the writer collected at Lewes, on Aug. 14, 1907, the aecidium on Hydrocotyle. The aecia were old and there was no evidence of uredinia or telia of *P. Hydrocotyles* (with which form the aecidium has previously been combined) on any of the affected leaves or on other plants in the vicinity. Surrounding the plants, however, were plants of *Scirpus americanus* abundantly affected with the uredinia of *U. Scirpi*. Observations and collections were again made in the same spot on June 6, 1908, when aecia were again found in abundance showing evidence of having been mature for about two weeks. A few culms of Scirpus were growing in such a position that the tips were hanging immediately above the Hydrocotyle plants bearing the aecia. On these tips fresh uredinial sori of *U. Scirpi* were present. No infection on Scirpus was found elsewhere at that date though the plants were very abundant over a wide area.

122. UROMYCES SEDITIOSUS Kern, Torreya 11:212. 1911.

Aecidium Plantaginis Burrill, Bull. Ill. Lab. Nat. Hist. 2:232. 1885.

Nigredo seditiosa Arth. N. Am. Flora 7:225. 1912.

ON POACEAE:

Aristida sp., Lewes, 1908.

Culture experiments reported by Arthur (Bot. Gaz. 35:17. 1903) prove the aecidial stage of *Uromyces Aristidae* to be *Aecidium Plantaginis.* He used telial material on *A. oligantha* Michx. from Texas and successful infection of *Plantago Rugelii* was obtained followed by pycnia and aecia.

Field observations made by Arthur and Fromme indicate also that *Aecidium Oldenlandianum* Ellis & Tracy, which occurs on various species of Houstonia in the southern states, also belongs here though confirming cultures have not yet been made.

123. UROMYCES SILPHII (Burrill) Arth. Jour. Myc. 13:202. 1907.

Aecidium Silphii Sydow, Ured. 1546. 1901.

Nigredo Silphii Arth. N. Am. Flora 7:239. 1912.

ON JUNCACEAE:

Juncus dichotomus Ell., Sussex Co., June 18, 1875, A. Commons.

Juncus tenuis Willd., Lewes, Aug. 14, 1907, (1700); Newark, Aug. 23, 1907, (1714); Sept. 1907, (1823, 1824); Selbyville, Oct. 4, 1907, (1793, 1800).

Arthur (Jour. Myc. 13:202. 1907; 14:17. 1908) has shown that this common species has its aecia on Silphium. Using telial material on *J. tenuis* from Indiana, West Virginia and Nebraska, five successful infections of *Silphium perfoliatum* were obtained, all of which resulted in the development of pycnia and aecia. The aecia on Silphium have been collected, so far as known to the writer, only in the Mississippi Valley from Ohio to Wisconsin, Kansas and Missouri, on three species of Silphium. The range of the telial collections referred here, however, is much greater including nearly the entire United States and Canada except the south Pacific slope. It seems probable that some plants other than Silphium, at present unrecognized, also serve as aecial hosts for this species. From field observations it seems probable that certain species of Aster serve as hosts for the aecia of this species in some localities.

This species is distinguished from the only other Uromyces on Juncus occurring in the eastern United States (*U. Junci-effusi* Syd.) which occurs commonly on *J. effusus*, by the number and position of the pores in uredospores. In *U. Silphii* there are two superequatorial pores; while in *U. Junci-effusi* the pores are 3-4 and equatorial.

124. Uromyces Spermacoces (Schw.) Curt. Cat. Pl. N. Car. 123. 1867.

Puccinia Spermacoces Schw. Schr. Nat. Ges. Leipzig 1:74. 1822.

Nigredo Spermacoces Arth. N. Am. Flora 7:266. 1912.

On Rubiaceae:

Diodia teres Walt., Newark, Sept. 18, 1905, (1627); Selbyville, Oct. 4, 1907, (1934); Cooch's Bridge, Sept. 18, 1915, C. O. Houghton.

This is doubtless an autoecious form though no cultures have been conducted. It is a very common species in the south and south central States. The above collections are near the northeastern limits of its range.

Unconnected Forms.

125. Aecidium Apocyni Schw. Schr. Nat. Ges. Leipzig 1:68. 1822.

On Apocynaceae:

Apocynum pubescens L., Seaford, July 9, 1907, (1649, 1653), June 4, 1907, (2053); Clayton, July 24, 1907, (2253).

This Aecidium is known otherwise only from North Carolina and New Jersey on the above host and on *A. cannabinum* L. only from the District of Columbia and North Carolina (according to Schweinitz). It is easily separated from *Aecidium obesum* Arth., which occurs on *A. Sibiricum*, by the possession of a firm peridium and much smaller aeciospores with thin walls. The latter agrees with *A. Cephalanthi* Seym. which has been shown by Arthur (Jour. Myc. 12:24. 1906; Mycol. 1:236. 1909; 4:19. 1912) to be the aecial form of *Puccinia Seymouriana* Arth. with uredinia and telia on Spartina.

126. Aecidium Compositarum Authors.

On Carduaceae:

Rudbeckia triloba L., Naamans Creek, April 27, 1894, A. Commons.

This Aecidium like many others on Compositae is doubtless heteroecious and may belong with telia on some Cyperaceous or Juncaceous

host. Since its exact affinities are at present unknown it is best for the present referred to as above.[1]

127. **Aecidium Ivae sp. nov.**

O. Pycnia amphigenous, crowded in yellowish spots, 3-15 mm. in diameter, noticeable, subepidermal, light yellow to light chestnut-brown, punctiform, 80-160 by 95-160μ, ostiolar filaments up to 80μ long.

I. Aecia usually hypophyllous, sometimes amphigenous, crowded on spots with the pycnia, cupulate, 0.2-0.4 mm. in diameter; peridium brownish yellow, recurved, erose; peridial cells rhomboidal in longitudial section, 19-27 by 35-51μ, overlapping, wall 5-7μ thick, outer wall smooth, transversely striate, inner wall closely and coarsely verrucose; aeciospores globoid or ellipsoid 21-29 by 26-23μ; wall colorless or pale yellow, 2-3μ thick, finely and closely verrucose.

ON AMBROSIACEAE:

Iva ovaria Bartlett (*I. frutescens* A. Gray not L.), Lewes, Aug. 14, 1907, (1676).

This species is evidently a heteroecious form and occurs otherwise, so far as is known, in salt marshes along the Atlantic coast and Gulf of Mexico in Virginia, Florida and Louisiana. It differs from *Aecidium intermixtum* Pk. (*Puccinia intermixta* Pk.) in the larger aeciospores and in the fact that the aecia develop from a limited mycelium.

128. AECIDIUM UVULARIAE Schw. Nat. Ges. Leipzig 1:69. 1822.

ON CONVALLARIACEAE:

Uvularia sessifolia L., Seaford, June 4, 1908, (2059); Cooch's Bridge, May 25, 1915, C. O. Houghton.

The above Aecidium is scarcely distinguishable from *Aecidium Majanthae* Schum. which has been shown by European investigators to be connected with uredinia and telia on Phalaris. In America aecidia occurring on Salamonia, Unifolium and Vagnera have been similarly referred to *P. Majanthae* (Schw.) Arth. (*P. sessilis* Schw.) though no successful cultures have been made. Since slight morphological differ-

[1] Since the above was written cultures conducted in this laboratory and reported by Arthur (Mycol. 9:307. 1917) show that aecia on *Rudbeckia laciniata* are genetically connected with uredinia and telia on Carex referred to *Uromyces perigynius* (cf. 114). He obtained successful infection resulting in aecia on *R. laciniata* following exposure to germinating telia on *Carex sparganioides*. It is therefore probable that the collection listed here from Delaware on *R. triloba* should be similarly referred.

ences exist between the form on Uvularia and those mentioned above it seems desirable to retain it as a separate species for the present.

129. UREDO ANDROMEDAE Cooke, DeToni in Sacc. Syll. Fung. 7:853. 1888.

ON ERICACEAE:

Pieris mariana (L.) Benth. & Hook., Wilmington, Oct. 1891, A. Commons (in E. & E. N. Am. Fungi 2717).

Xolisma ligustrina (L.) Britt., Selbyville, Oct. 4, 1907, (1941).

This species, included by Arthur in *Melampsoropsis Cassandrae* (P. & C.) Arth. (N. Am. Flora 7:119. 1907) is clearly not that species, as the urediniospores are echinulate. Its affinities are probably with Pucciniastrum. The ostiolar cells of the peridium however are not well developed and it seems best to retain it under the above name for the present.

INDEX TO SPECIES.

Host Index.

Purdue University, Lafayette, Ind.

THE TREES OF WHITE COUNTY, INDIANA

WITH SOME REFERENCE TO THOSE OF THE STATE

A Thesis

Submitted to the Faculty of Purdue University

by

LOUIS FREDERICK HEIMLICH

Candidate for the Degree of Master of Science

June, 1916

is papei was submitted for publication in the 1916 Proceedings, but the publication was deferred one ear on account of the many long papers submitted n 1916.—EDITOR

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The Trees of White County, Indiana, with Some Reference to Those of the State.

For a long time botanists have been busy describing species and working out their distribution over the surface of the earth. Dendrologists, more particularly, have been contented with the description and distribution of trees. From studies and reports made thus far, the general ranges of trees and most flowering plants are fairly well known. One might well suspect what plants grow in a certain area, but definite reports are to be preferred.

Now the significant way to study vegetation is from an ecological standpoint. Completeness is not attained by noting the species of a certain group within any political boundary. Armed with the reliable information of a geologist, the distribution and number of species and individuals, from unicellular plants in the soil and water to the most complex flowering types, should be worked out by the taxonomist-ecologist. This of course would take time, but taking each county, or stream and then working in the intervening spaces, as a unit for the working field, the completed report would show a new natural map with a far greater meaning than isolated and incomplete reports coming from various sections. This would become very far-reaching, taking into account plant diseases, and, being but a step to animal parasites on plants, an account of the complete fauna of the region as well as a complete flora as hinted at above, would be still more desirable. We should then have some really effective Life Zones.

A complete flora for the State is the aim of the committee on the Biological Survey of the Indiana Academy of Science. To my knowledge there is no similar committee or thought of a complete fauna for the State.

The Indiana State Board of Forestry is interested in determining just what species of trees grow in Indiana and just what their ranges in the State are. In the Eleventh Annual Report of the State Board of Forestry, 1911, is to be found the most authentic record of Indiana trees up to the present time. There is no pretense that the report is complete either for the total number of species in the State, or much less so for the ranges of those reported. Some counties have been very thoroughly worked, others only partly, and some not at all—at least

reports are lacking. White County happens to fall into this last category.

Under these circumstances the general aim of this thesis has been a systematic report on the Native Trees of White County, their species and relative numbers. Other related features have been included as the result of a growing interest in the subject. The matter of ecology was thought of seriously, but due to the lack of time and the as yet unavailable soil report of the county*, this part has been reduced to a very brief review of the physical and geographical aspects of the county, and a consideration of the Tippecanoe River trees, with the general distribution of trees over the county. As regards the economic phases of White County trees, some isolated but interesting figures were obtained. In this connection some historical data attaches another bit of interest. Comparisons with State and national distribution by the use of maps, illustrate clearly among other things the need for further work as well as the correction of past limits or errors. Attention is also called to a new list of Hickories for the State according to Sargent's latest determinations. Besides other minor features which need not be mentioned here, I have been fortunate enough to include a new variety of willow for the State, and possibly a new species of that same genus.

Geographical and Physical Aspects of White County.

Before proceeding at once to the primary aim of this thesis, the report of species and relative numbers, I have deemed it desirable to point out certain other features, giving a general notion of the county, topography, fertility of soil, drainage, transportation facilities, etc.

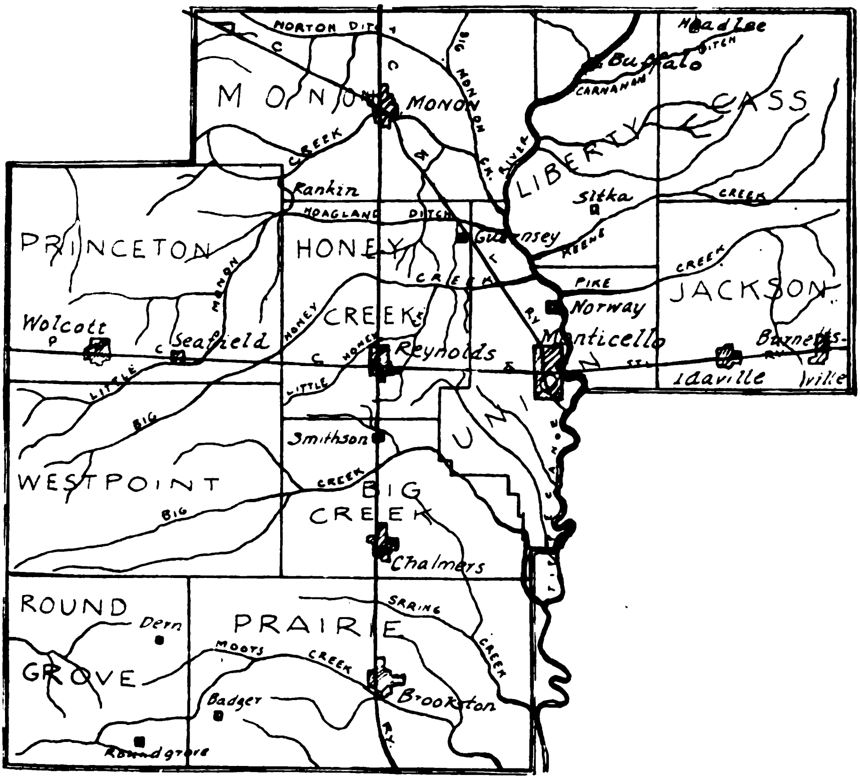
White County is located in the northwestern part of Indiana and possesses some of the best agricultural land in the world. The soil is especially fertile in the southwestern half of the county, which is prairie land. Black, rich soil in this area produces monster crops of corn and oats, with nearly all the ground surface taken up in cultivation. Comparatively less timber is to be found in this region and very likely the region has always been the less wooded part of the county—being formerly a vast sea. Boulders of the glacial age in many cases have been removed to the fence rows.

* Soil Survey made by U. S. Bureau of Soils, Summer 1915.

Plate I.

WHITE COUNTY.

507 Square Miles—324,480 Acres.



Low sand ridges are especially characteristic of Honey Creek and Monon townships and also parts of Princeton. This area is very densely covered with forests of oak (almost exclusively Q. alba, palustris, velutina, coccinea).

In the environs of the Tippecanoe River and eastward the topography is rather more rugged. Very good farm lands are also found in this area. Formerly almost every foot of this region was heavily wooded.

The following statistics, taken from the U. S. 1910 Census, give some notion of the fertility and returns of White County soils.

(TABLE 1.)

Total land area in acres		324,480
Acres under cultivation:		
Cereals	165,106	
Hay	28,550	
Potatoes	750	
All other crops	893	
Small fruits	35—	195,334
Per cent of total land area cultivated		60
Number of farms		2,091
Average number of acres per farm		150.4
Value of all crops (except nuts, etc.)		$2,951,637
Expense:		
Labor	$184,833, or 88%	
Fertilizer	23,758, or 12%—	208,591.00
Net crop returns		$2,743,146.00
Net returns per acre		14.04
Land value per acre		77.69
Per cent of net per acre to value per acre		18.2

The total population in 1910 (U. S. Census) was 17,602 with only 6,511 as being included in towns.

Nearly all of the 507 square miles in White County are drained by the Tippecanoe River and its tributaries. The county as a whole is rather flat and much dredging and tile-ditching has been done in recent years. Parts of natural streams have been dredged several times and also extended. Possibly in this case more erosion would be gladly welcomed. The Tippecanoe is a geologically young and very beautiful watercourse, fed by clear lake-water at its head in Noble County and by numerous springs along its banks.

Since national and local interests are crystallizing more and more in the direction of natural beauty spots—parks and pleasure resorts—I suggest that very appealing tracts can be found along the Tippecanoe, especially north of Monticello, near Norway and up toward Buffalo.

Transportation facilities in the county are excellent. The Monon and Pennsylvania Lines cross the county. A system of good roads is in existence, about 400 miles of which are macadamized or made of gravel.

Limestone quarries are located at Monon and recently other deposits have been found several miles southwest of Reynolds. Good clay deposits and tile factories at Chalmers, Seafield and Wolcott have been in operation for a number of years.

A far more accurate and much more detailed statement covering the part here alluded to will be found in the forthcoming report of the U. S. Bureau of Soils for White County, which will be ready for distribution within a few months.

The Native Species of Trees.

Parts of the summer of 1915 and the fall of 1914 were spent in making collecting trips over various parts of the county. The regular routine work was done single-handed, and the specimens disposed of and mounted according to standard methods now form a permanent part of my private herbarium.

Realizing very thoroughly that the work of determination, especially in some genera, is not such a self-satisfying matter to any careful botanist, I endeavored to make my collection as authentic as possible. Any specimen still remaining in doubt is either entirely omitted or expressly given as doubtful.

Specimens in the Purdue Herbarium and many specimens of Oaks and Hickories, collected last summer by Mr. Deam and Prof. Hoffer and recently determined by Sargent, were available for comparison. Dr. Sargent has verified or determined all the specimens of Salix, Hicoria, Crataegus, Malus, and many Oaks. Mr. F. W. Pennell, Assistant Curator of the New York Botanical Garden, has determined specimens of Fraxinus and Cornus. Mr. W. W. Eggleston of the Bureau of Plant Industry was also consulted. I am permitted to add Salix longifolia variety argophylla (determined by Sargent) to my list, by the courtesy of Mr. C. C. Deam of Bluffton, Indiana, who was ever ready to help. Acknowledgments are also due Professor G. N. Hoffer of Purdue, not least of which are for a kindly interest in the work. Grateful appreciation to Dean Stanley Coulter, under whom this thesis was written, is here expressed, for help, encouragement and his stamp of approval.

Thanks are also tendered to Mr. Ed Newton of Monticello, Indiana, for historical accounts, and to my sister Frieda for data in connection with Part V.

As designated in the 1911 Report of the State Board of Forestry, "the number of trees included in this list is wholly arbitrary," so I have included some species—small trees, or large shrubs, not considered in that report. Further consideration of each species is deferred to another part of this paper.

The following is a complete list of all species collected:

(List 1.)

NATIVE WHITE COUNTY TREES.

Juniperus virginiana L.
Salix amygdaloides Anders.
 interior Rowlee.
 humulis Marsh.
 discolor Muhl.
 nigra Marsh.
 missouriensis Bebb.
 longifolia var. argophylla Sarg.
Populus alba L.
 grandidentata Michx.
 heterophylla L.
 tremuloides Michx.
 deltoides Marsh.
Juglans nigra L.
 cinerea L.
Hicoria cordiformis (Wang) Britton.
 ovata (Mill) Britton.
 laciniosa (Michx) Sarg.
 alba (L) Britton.
 ovata var. fraxinifolia Sarg.
Corylus americana Walt.
Carpinus caroliniana Walt.
Ostrya virginiana (Mill) Willd.
Betula lutea Michx.
Fagus grandifolia Ehrh.

Quercus alba L.
macrocarpa Michx.
bicolor Willd.
Muhlenbergii Englm.
rubra L.
palustris DuRoi.
coccinea Muench.
ellipsoidalis E. J. Hill.
velutina Lam.
imbricaria Michx.
Ulmus americana L.
fulva Michx.
Celtis occidentalis L.
Morus rubra L.
Toxylon pomiferum Raf.
Liriodendron tulipifera L.
Asimina triloba (L) Dunal.
Sassafras variifolium (L) Karst.
Hamamelis virginiana L.
Plantanus occidentalis L.
Malus malus (L) Britton.
ioensis (Wood) Britton.
Amelanchier canadensis (L) Med.
Crataegus crus-galli L.
pruinosa (Wendl) Koch.
albicans Ashe. ?
calpedendron (Ehrh) Britton.
Prunus americana Marsh.
serotina Ehrh.
Cercis canadensis L.
Gleditsia triacanthos L.
Gymnocladus dioica (L) Koch.
Robinia Pseudo-acacia L.
Zanthoxylum americanum Mill.
Ptelea trifoliata L.

Rhus glabra L.
copallina L.
hirta (L) Sudw.
Ilex verticillata (L) A. Gray.
Staphylea trifolia L.
Acer negundo L.
saccharum Marsh.
saccharinum L.
nigrum Michx.
Aesculus glabra Willd.
Tilia americana L.
Nyssa sylvatica Marsh.
Cornus alternifolia L.
stolonifera Michx.
asperifolia Michx.
femina Mill.
florida L.
Fraxinus americana L.
pennsylvanica Marsh.
Cephalanthus occidentalis L.
Viburnam Lentago L.
prunifolium L.
Sambucus canadensis L.

It may and likely will be necessary to add a few species not included in the above to make the list complete. Such probable species occurring in the county are considered in the list dealing with the details of each species. The following is merely a suspected list of those species.

(List 2.)

SPECIES LIKELY TO BE FOUND IN WHITE COUNTY.

Salix alba L.
lucida Muhl.
Hicoria microcarpa (Nutt) Britton.
glabra (Mill) Britton.
Alnus rugosa (DuRoi) Spreng.
Crataegus margarette Ashe.
succulenta Schra.

Acer rubrum L.
Fraxinus quadrangulata Michx.
        nigra Marsh.
Morus alba L.

It is stated in the 1911 Report (p. 87) that "it is believed that about one-half of our trees are found in nearly every county of the State." In that report forty-seven genera with 125 species of trees are considered. The following table compares the number of species for each genus as given in the report, with the number of the same species in the same genus for White County. Other species in the same genus not reported are added in a third column. Varieties and species of still other genera are included in other columns.

Recalling the statement referred to above, it will be seen that White County has representatives of over half the genera and about "one-half" the species, there being 33 out of 47 genera represented, with 62 species.

TABLE II.

Table Comparing Number of Genera and Number of Their Species Reported for Indiana, with Number of Same Genera and Same Species for White County.

Genus.	Species for Indiana.	Species for White Co.	Other Species in White County not Given in 1911 Report.	Species of Other General Included.
Pinus	3	0		
Larix	1	0		
Tsuga	1	0		
Taxodium	1	0		
Thuja	1	0		
Juniperus	1	1		
Salix	4	2	4 and 1 variety.	
Populus	5	5		
Juglans	2	2		
Hicoria	7	4	4 and 1 variety.	Corylus ... 1
Carpinus	1	1		
Ostrya	1	1		
Betula	1	1		
Alnus	2	0		
Fagus	1	1		
Castanea	1	0		
Quercus	17	10		
Ulmus	4	2		
Celtis	3	1		
Morus	2	1		
Toxylon	1	1		
Magnolia	1	0		
Liriodendron	1	1		
Asimina	1	1		
Sassafras	1	1		Hamamelis....1
Liquidamber	1	0		
Platanus	1	1		
Malus	2	1	1	
Amelanchier	1	1		
Crataegus	18	4		
Prunus	4	2		
Cercis	1	1		
Gleditsia	2	1		
Gymnocladus	1	1		
Robinia	1	1		
				Zanthoxylum..1
				Ptelea.........1
Ailanthus	1	0		
				Rhus..........1
Ilex	1	0	1	
				Staphylea.....1
Acer	5	4		
Aesculus	2	1		
Tilia	2	1		
Nyssa	1	1		
Cornus	2	2	3	
Diospyrus	1	0		
Fraxinus	6	2		
Forestiera	1	0		
Catalpa	2	0		
				Cephalanthus. 1
Viburnam	2	2		
				Sambucus.....1
Total	125	62	9 and 2 varieties.	8

Total number of Genera: Indiana, 47; White County, 34.

Below is appended a partial list of cultivated trees known to exist in White County.

(List 3.)

PARTIAL LIST OF CULTIVATED SPECIES OF TREES IN WHITE COUNTY, OMITTING THE USUAL ORCHARD TREES.

Gingko biloba	Gingko or Maidenhair Tree.
Thuja occidentalis L.	Arbor Vitae.
Chamaecyparis obtusa?	Cypress.
Picea abies (L) Karst	Norway Spruce.
Larix larcina (DuRoi) Koch	Larch-Tamarack.
Populus nigra L.	Black Poplar.
var. italica DuRoi	Lombardy Poplar.
Castanea dentata (Marsh) Borkh	Chestnut.
Aesculus Hippocastanum L.	Horse-chestnut.
Ailanthus glandulosa Desf.	Tree-of-Heaven.
Acer palmatum	Japanese Maple.
Acer spicatum Lam.	Mountain Maple.
Rhus cotinoides Nutt	Smoke Tree.
Pyrus americana (Marsh) DC.	American Mountain Ash.
Viburnam opulus L. var. americanum (Mill) Ait.	Cranberry Tree.
Diospyrus virginiana L.	Persimmon.
Catalpa speciosa Warder.	Catalpa.
catalpa (L) Karst.	Catalpa.
Kaempferi.	Japanese Dwarf Catalpa.
Betula alba L.	European White Birch.

IV. DISTRIBUTION.

1. GENERAL INTIMATION.

As noted previously, White County embraces 507 square miles or 324,480 acres. I have often been over much of this area and have in a general way for a long time known most of the trees. In making a definite report, however, a definite procedure seems to be desirable.

The map on page 402 shows the territory covered during the last summer. The red lines represent the actual highways travelled, mostly by bicycle, some by automobile. Many side trips were made on foot.

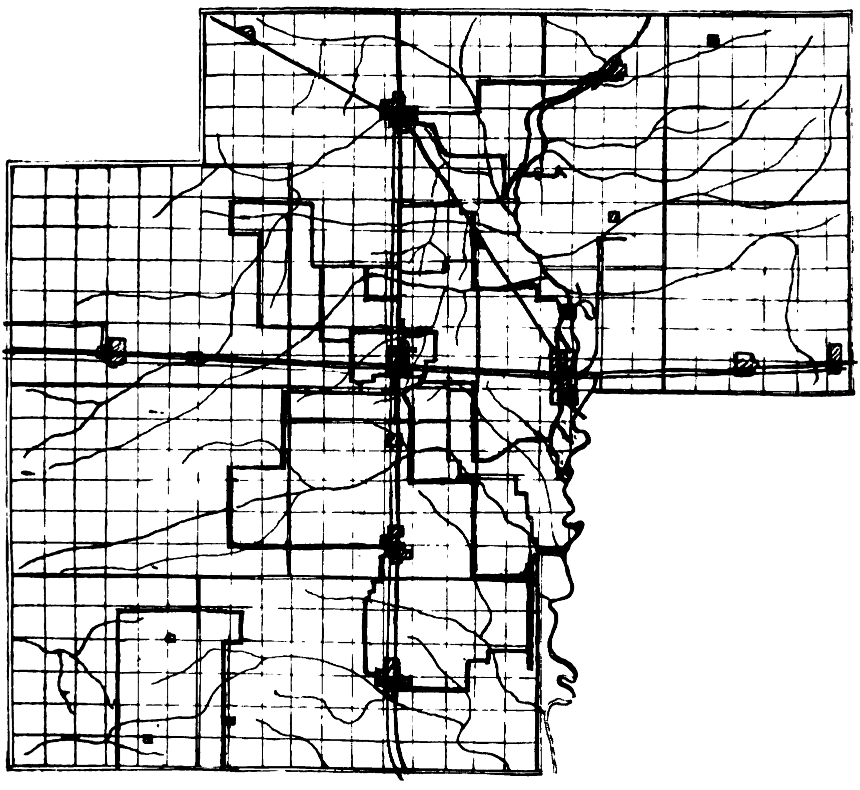
As I recall it, many days were totally unfit for the collector owing to the continuous heavy rains. As a result of this many thickets were miry or filled with water. As a further consequence, the mosquito hordes too often interfered with the pleasure of the work if nothing else. Such experiences, more or less trivial, must be evident to most collectors and serve only to hint at other difficulties besides those of determination.

In attempting to say something about the distribution of each species in the county, references are made to the general distribution and

Plate II.

WHITE COUNTY.

Red Lines Show Actual Roads Traveled in Collecting Specimens.



the reported distribution in the State. Some maps covering these features reveal several matters of interest. First, it becomes evident that the definition of the general limits of any species is a big task, always changing, and a graphical representation of a number of species for Indiana shows quite clearly, among other things, that some counties have been quite thoroughly worked, whereas others have had little or no attention at all. Elkhart, Benton, Clinton, Jasper, Newton, Ohio, Perry, Pike, Pulaski, Rush, Switzerland, Tipton, Vanderburgh, Warrick, Whitley and White Counties are not mentioned in a single published report. As the maps show, the counties bordering on the Wabash River and extending in a continuous line from Posey to Steuben County, have been the most thoroughly worked, as have Wells County (by Deam), the group of Delaware, Jay, Randolph and Wayne (by Phinney), Jefferson (by Coulter), Clark (Baird and Taylor), area of New Albany, Floyd (Clapp), Hamilton (Wilson), and Franklin (Meyncke). (See Range maps pp. 424-429, 444, 450, 453, 456, 460, 461.)

Nearly two decades ago Dr. Cowles of the University of Chicago made an ecological study of the shores of Lake Michigan. The results of his investigations were published in the Botanical Gazette. Though none of these contain a definite list of plants for the borders of the Indiana Dune area on Lake Michigan, I have been able to pick out a number of trees mentioned in the articles as occurring in that area. And since these references seem to have had no acknowledgments in later records, I include a list of trees below, taken mostly from the Botanical Gazette, Vol. 27, No. 4, April, 1899. Most of the species occur at Dune Park in Porter County.

(List 4.)

Some Trees of the Dune Area of Indiana.

Pinus strobus L.
    Banksiana Lamb.
Abies balsamea (L) Mill.
Tsuga canadensis (L) Carr.
Thuja occidentalis L.
Juniperus virginiana L.
    communis L.

Salix glaucophylla Bebb.
adenophylla Am. auth., not Hook.
humilis Marsh.
Populus monilifera Ait. (P. deltoides Marsh).
balsamifera L.
Juglans cinerea L.
Ostrya virginiana (Mill) K. Koch.
Betula payrifera Marsh.
Fagus ferruginea Ait. (F. grandifolia).
Quercus coccinea tinctoria A. DC. (Q. velutina Lam.).
alba L.
Ulmus fulva Michx.
Celtis occidentalis pumila Muhl.
Sassafras officinale Nees and Eberm.
Hamamelis virginiana L.
Amelanchier canadensis (L) Med.
Prunus pumila L.
virginiana L.
Ptelea trifoliata L.
Rhus canadensis Marsh.
copallina L.
Acer saccharinum L.
Tilia americana L.
Cornus stolonifera Michx.
florida L.
Fraxinus americana L.
Viburnam acerifolium L.

The Range maps included for the distribution of some selected species indicate the opportunity for someone to make a careful collection, an accurate determination and a report, covering one or more counties, either to the State Board of Forestry or the chairman of the Committee on the Indiana Botanical Survey.

When reports for all counties are complete it will be interesting to note from just what counties certain species are actually absent and to seek the reason for this absence in terms of ecology or otherwise.

Besides the matter of distribution in itself, I have endeavored to

add other details of more or less importance. The following, then, is a brief consideration of each species collected in White County—first the Oaks, next the Hickories, a study of the Tippecanoe flora, followed by the Willows and other species generally distributed over the county.

2. The Oaks.

The Oaks constitute the most important trees in White County in point of utility and quality as well as in number of species in any one genus represented, or as regards the number of individuals in the genus.

Seventeen species of oaks have been reported for Indiana. This is the number contained in both, Coulter's Flora and in Deam's 1911 Report. The former, however, lists Quercus texana Buckley (Texan Red Oak—Gibson, Posey, Knox—Dr. Schneck?) and Q. Phellos L. (Willow oak—Gibson, Posey, Knox)—omitting Quercus Schneckii Britton (Schneck's oak), and Q. ellipsoidalis E. J. Hill (Hill's oak).

Quercus Schneckii Britton is a species yet in doubt (Deam). It may be referable to Q. texana, but the new flora of Britton and Brown says it "has been confused with Q. texana." It closely resembles Quercus rubra L. and may supplant the latter to an unaware extent. Thus far it has been reported from Bartholomew (Elrod); Gibson, Knox, Posey and Vermillion (Schneck); Knox (Ridgway); Posey and Wells (Deam). "It is believed that it is more or less frequent along the Wabash and its tributaries," and so may occur in White County along the Tippecanoe or southeastern part of the county.

Quercus phellos L. references for Indiana have been changed to Q. imbricaria Michx. (See Deam, 1911 Report, pp. 91-92.)

Quercus ellipsoidalis E. J. Hill was described (E. J. Hill, Bot. Gaz. 27:204, 1899) after Coulter's Catalogue was published.

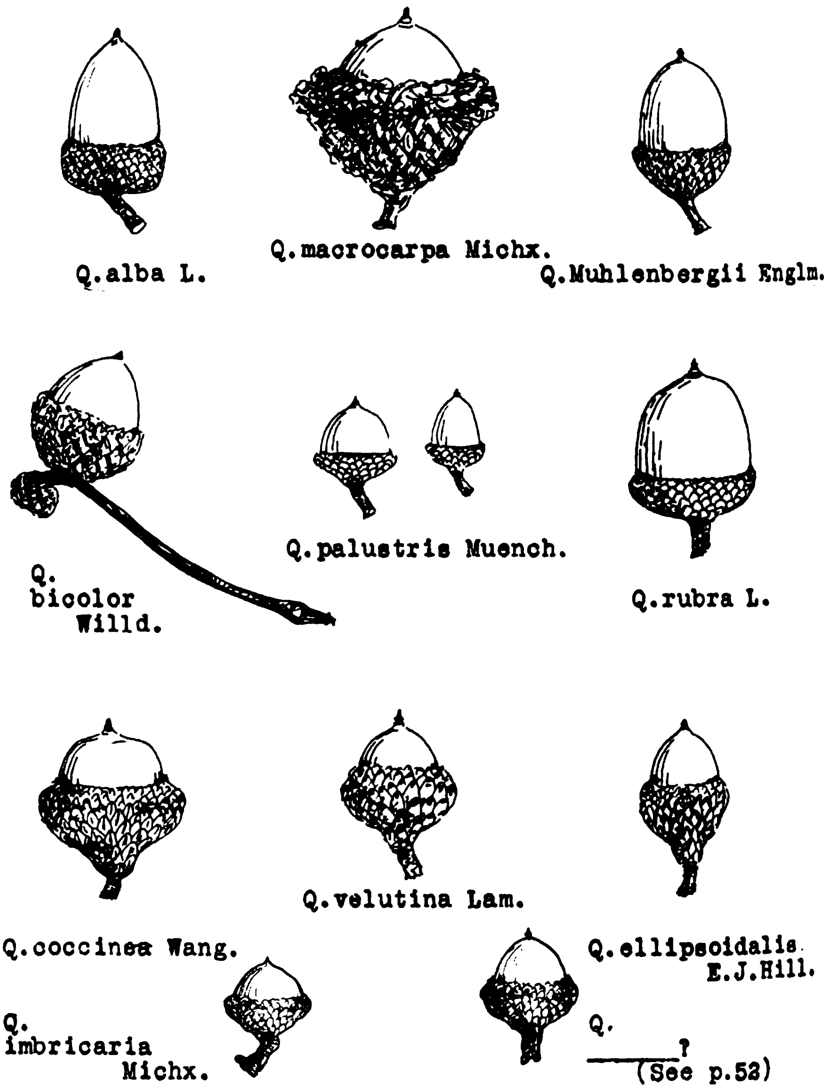
Other oaks (Q. ilicifolia Wagn. and Q. nigra L.) have been reported for our area, but for apparently sufficient reason have been referred to other species, being in most cases variant forms. (1911 Report p. 91.)

Ten out of the seventeen species reported for Indiana were found in White County. Of the seven remaining species, Q. lyrata Walt., Q. Michauxii Nutt., Q. falcata Michx., are quite restricted to the extreme southwestern counties; Q. stellata Wang., Q. Prinus L., and Q. marylandica Muench., are southern or local; the distribution of Q. Schneckii is discussed above.

PLATE III.

TYPICAL ACORNS

Of Oaks Indigenous to White County.



Just exactly how generally some of the ten species collected are distributed over the county I am unable to say. This matter will be discussed with each species separately.

The White Oaks.

Four species of the White Oak group appear in White County. These in point of number of individuals, rank as follows: (1) Q. alba L. (2) Q. macrocarpa Michx. (3) Q. bicolor Willd. (4) Q. Muhlenbergii Engelm.

Quercus alba L. White Oak. (Sp. Pl. 996-1753.)

The White Oak is one of the most numerous and perhaps the most valuable tree of the county. The largest of these trees, as well as many others of less maturity, have long ago disappeared. Some fairly large trees are, however, still to be found. The species is quite generously distributed over the entire county.

The White Oak is readily distinguished from other oaks in spite of the fact that it shows much diversity, in nearly all parts, among individuals of its own small group or species. The bark character varies on many trees. On most younger trees and on many older ones it is comparatively thin and flaky. On not infrequent large trees it is rather deeply fissured with a thickness approaching three inches or more. The outer appearance of the bark on these trees is a peculiar gray as a rule, the inner part being a rich brown.

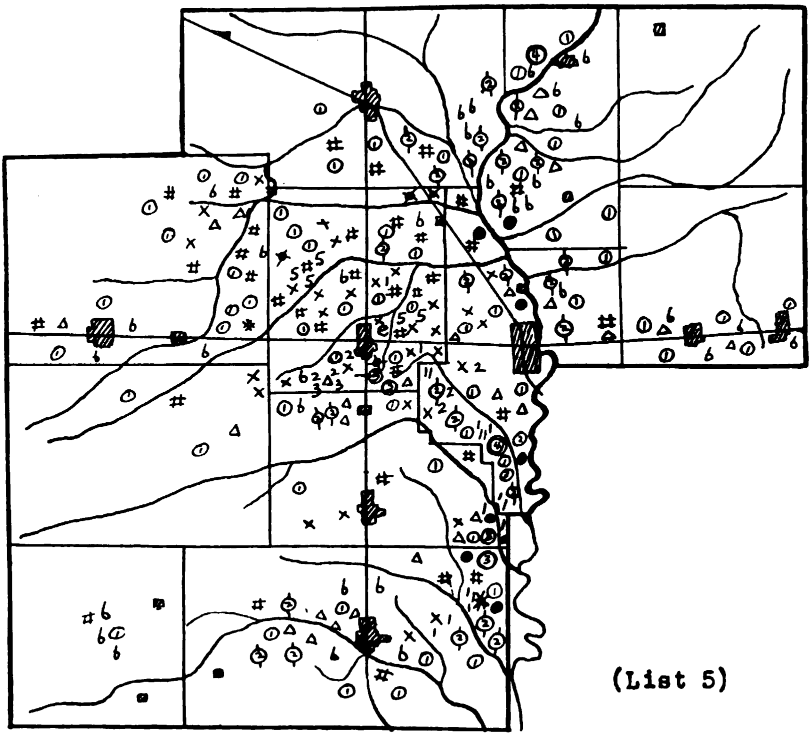
The leaves vary considerably in size and shape. Specimen No. 289 (p. 410), is the typical form. Nos. 443 and 257, also No. 446, show slight variation in size and shape. The leaves in No. 283 show a tendency toward less deep lobing and the one with the lobes more divergent are still further amplified in No. 467, giving a hint toward the leaf character of Q. stellata Wang. No. 292 is simply a large shallow lobed form. The lobes of Nos. 469 (p. 417) and 282 (p. 418) are extremely shallow and, by an amateur, the latter may be almost mistaken for the Swamp White Oak (Q. bicolor Willd.).*

A decided difference is also noted in the thickness of twigs and size of the winter buds in different individuals. In some, Nos. 469 (p. 417) and 282 (p. 418), the twigs are especially thin with correspondingly

* See Q. bicolor p. 411 for distinguishing leaf characters.

PLATE IIIi.

WHITE COUNTY.



(List 5)

General Distribution of the Oaks and Hickories

HICORIA

1 cordiformis(Wang)Brit.
2 ovata (Mill) Brit.
3 ovata var.fraxinifolia Sarg.
4 laciniosa (Michx.f.) Sarg.
5 alba (L) Brit.
6 unidentified.

(These ranges are incomplete).

QUERCUS

① alba L.
② macrocarpa Michx.
③ bicolor Willd.
④ Muhlenbergii Engelm.
● rubra L.
× palustris Muench.
✖ coccinea Muench.
e ellipsoidalis E.J.Hill.
✡ velutina Lam.
△ imbricaria Michx.
* -------? (See p.52).

small buds, due perhaps mostly to general shading of the trees from which these specimens were taken. In others, of which No. 446 (p. 414) is an example, the twigs are particularly heavy and large. This specimen also shows a decidedly vigorous type of acorn with a long stalk and a broad cup.

Some of the differences are so conspicuous and constant for a number of individuals that there appears to be several races or varieties in this species.

Scarcely more than a third of the counties (33) have reported this well-known tree. It would be interesting for others while reporting this species to note if these racial characteristics, if such, are found.

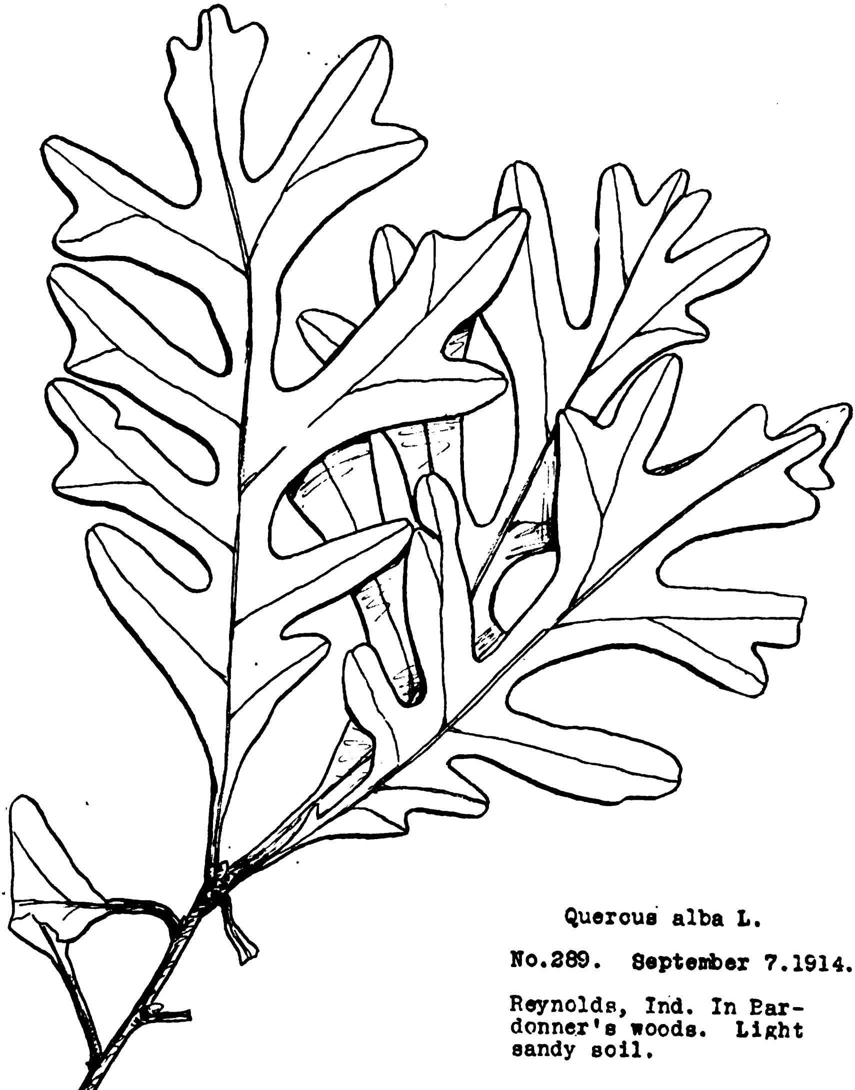
Quercus macrocarpa Michx. Mossy-cup, Blue or Bur Oak, Mossy-cup White Oak, Scrub Oak. (Hist. Chen. Am. 2 pl. 23, 1801. Q. olivaeformis Michx. f. 1812.)

The Bur Oak is more widely spread than perhaps any other oak in the United States. It has been reported from 30 counties in Indiana. In White County it occurs chiefly along the Tippecanoe and the lower stretches of the creeks emptying into that river. Not many trees were noted west of the Monon Railroad. A single tree of fair size, about three miles directly north of Reynolds, enjoys an isolation by a radius of several miles. A number of this species are to be found about two miles south of Reynolds. I very much doubt its occurrence in Princeton Township and likewise for Westpoint. It does, however, occur west of these places, for I have seen it in abundance along Carpenter Creek in Jasper County, near Remington. It is usually found in moist, rich soil, near or some small distance from streams. Specimens were taken from trees near the Ward School, three and three-fourths miles southeast of Reynolds. The Bur Oak leaves an impression of a rather coarse appearing tree throughout, easily distinguished from all other oaks.

Quercus bicolor Willd. Swamp White Oak. (Neue Schrift Geo. Nat. Fr. Berlin 3:396. 1801), (Quercus Prinus platanoides Lam. 1873. Q. platanoides Sudw. 1893).

The range of the Swamp White Oak in the United States is much more restricted than that of the two other white oaks here reported. In Indiana it is reported from 25 counties (scattering). It is very much less frequent in White County than other oaks. Several trees of

PLATE IV.



Quercus alba L.

No.289. September 7.1914.

Reynolds, Ind. In Bardonner's woods. Light sandy soil.

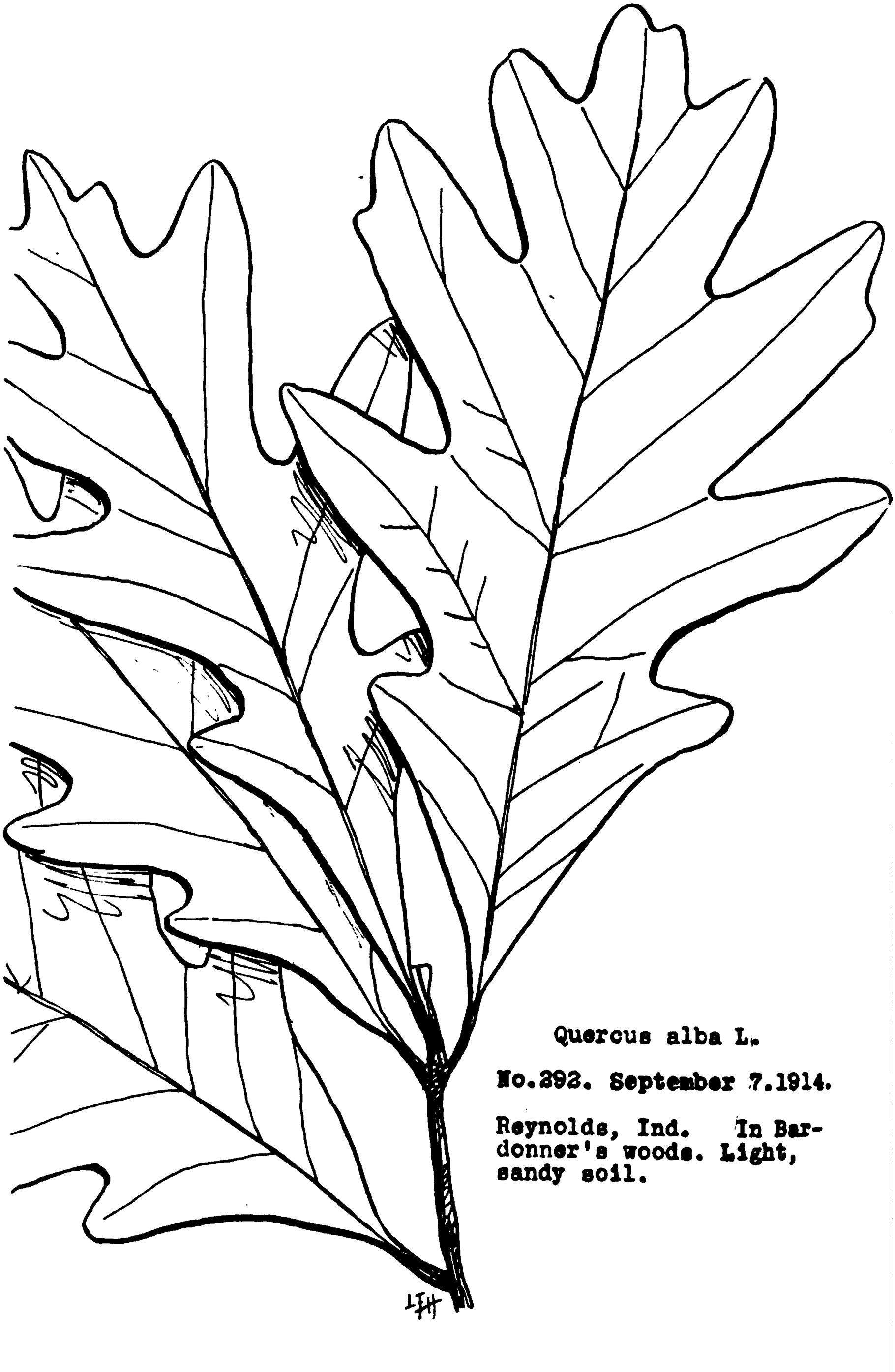
small size are to be found in Ward's thicket about one mile south of Reynolds. Other trees of this species were noted south of the Dyer school, five and three-fourths miles northeast of Brookston, near the Carroll County line. It is found exclusively in swampy or low, moist, rich soil.

The leaves of the Swamp White Oak are broadly obovate or oblong-ovate, rather coarsely round-toothed or pinnatifid. Unlike the White Oak the veins nearly always end in a glandular sharp tip. In the case of the White Oak there is more often a noticeable depression at the vein ending in the lobe. The bark on the younger branches peels back and curls over in a stiff and persistent papery layer, exposing the new lighter brown bark. This is quite characteristic, as is also the long-peduncled acorns.

Quercus Muhlenbergii Engelm. Chestnut or Yellow Oak, Chinquapin or Chinkapin, Oak, Tanbark Oak, etc. (Trans. St. Louis Acad. 3:391. 1887), (Q. Prinus acuminata Michx. 1801. Q. acuminata Sarg. 1895.)

This oak is reported from 35 counties in all parts of the State. It is sometimes confused with Q. Prinus L., resembling it closely, as the historical account above indicates. In White County it was noted only along the Tippecanoe River. The acorns readily distinguish it from other oaks indigenous to White County.

PLATE V.

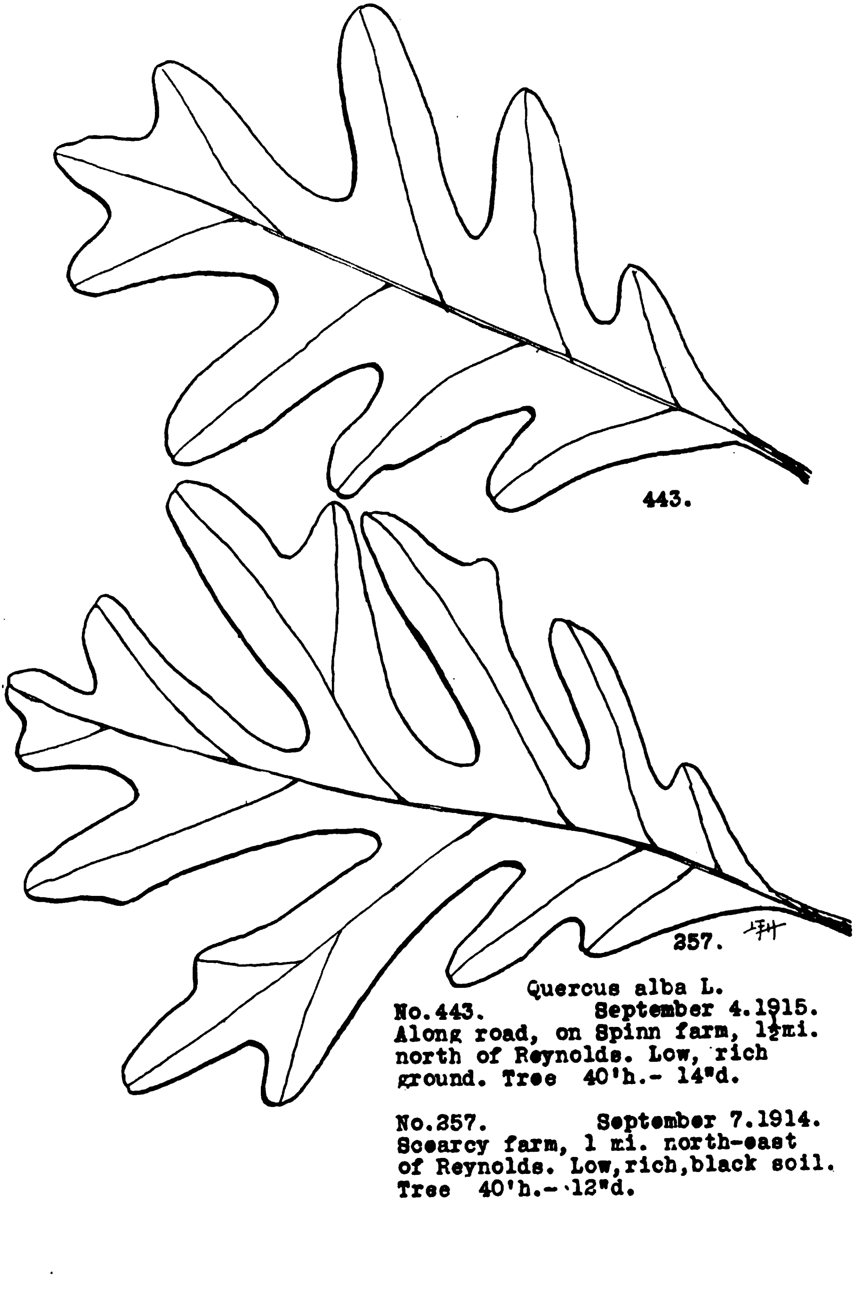


Quercus alba L.

No. 292. September 7. 1914.

Reynolds, Ind. In Bardonner's woods. Light, sandy soil.

PLATE VI.



443.

257.

Quercus alba L.

No.443. September 4.1915.
Along road, on Spinn farm, 1½mi.
north of Reynolds. Low, rich
ground. Tree 40'h.- 14"d.

No.257. September 7.1914.
Scearcy farm, 1 mi. north-east
of Reynolds. Low,rich,black soil.
Tree 40'h.- 12"d.

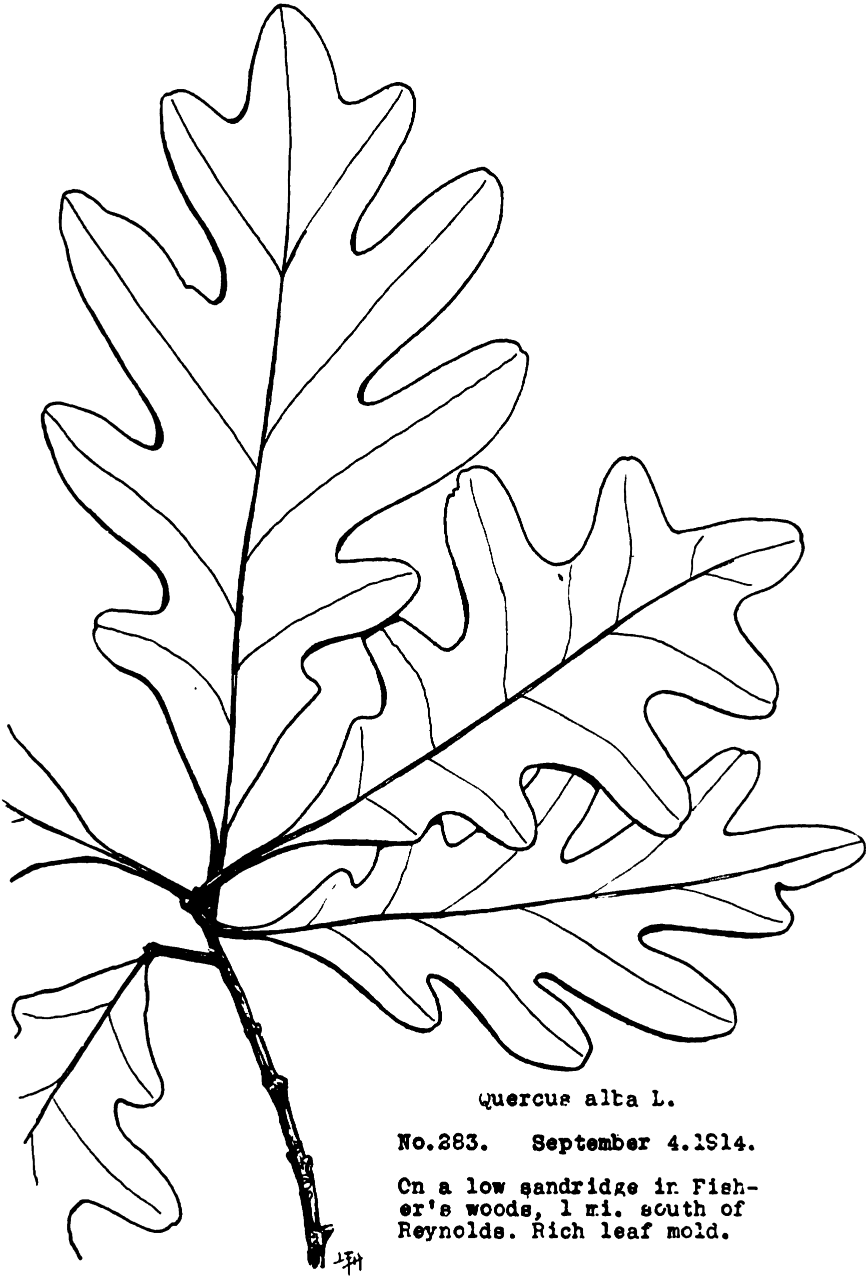
PLATE VII.

Quercus alba L.

No. 446. September 4. 1915.

North side of road, near Westfall farm house, 3 mi. north of Reynolds. Low elevation, a rich- sandy soil.

PLATE VIII.

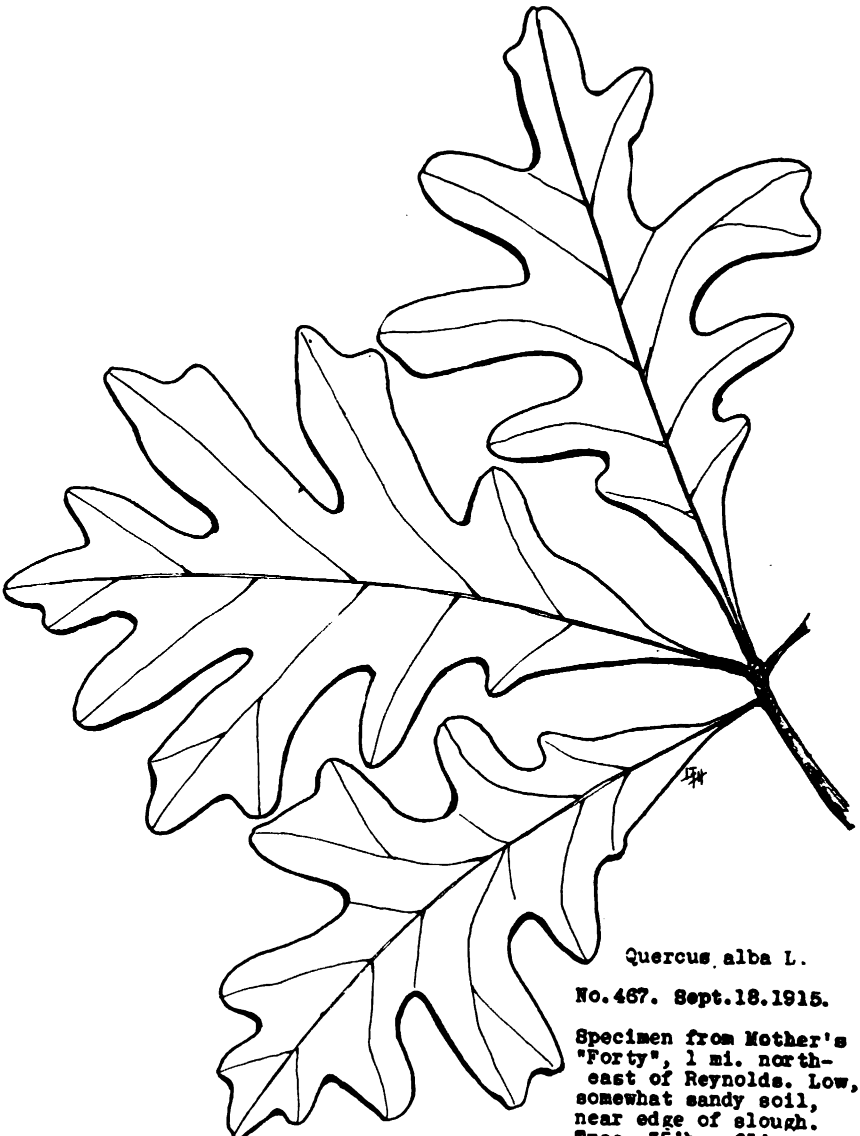


Quercus alba L.

No.283. September 4.1914.

On a low sandridge in Fisher's woods, 1 mi. south of Reynolds. Rich leaf mold.

PLATE IX.

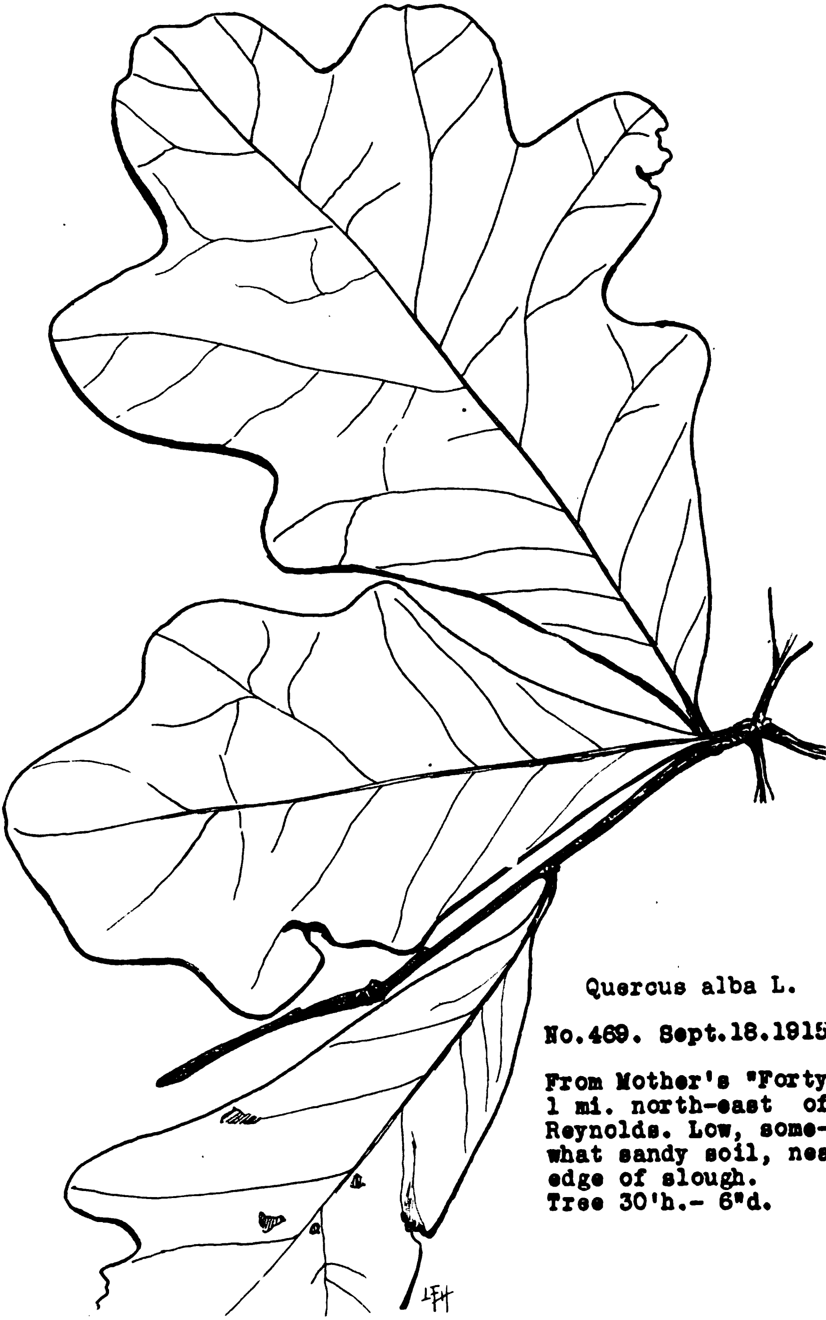


Quercus alba L.

No. 467. Sept. 18. 1915.

Specimen from Mother's "Forty", 1 mi. north-east of Reynolds. Low, somewhat sandy soil, near edge of slough. Tree 35'h.- 6"d.

PLATE X.

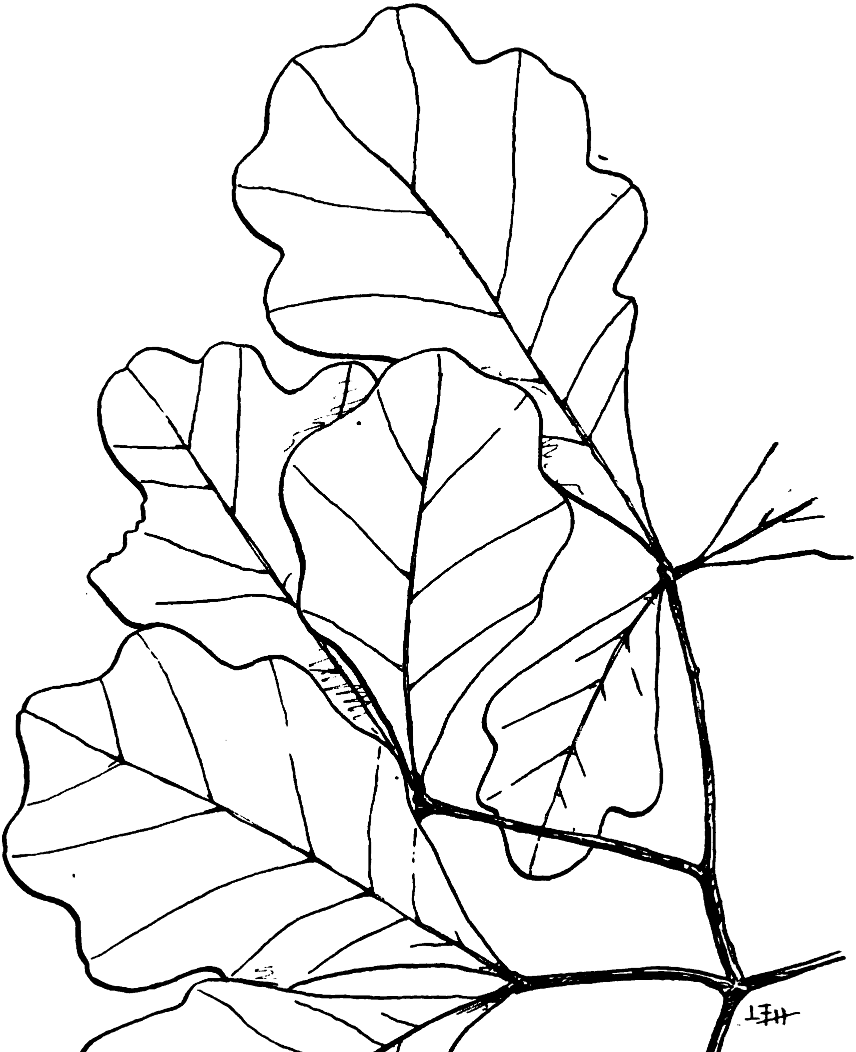


Quercus alba L.

No.469. Sept.18.1915.

From Mother's "Forty"
1 mi. north-east of
Reynolds. Low, some-
what sandy soil, near
edge of slough.
Tree 30'h.- 6"d.

PLATE XI.



Quercus alba L

No. 282. September 4. 1914.

Near edge of a low sand-
ridge, in Fisher's woods,
1 mi. south of Reynolds.
Tree 40'h.- 10"d.

PLATE XII.

Quercus bicolor Willd.

No.456. Sept.7.1915.

Along road,5¼mi.north-
east of Brookston,Ind.
South of Dyer school.
Low, rich,black soil.
Tree 30'h.- 6"d.
Swamp White Oak.

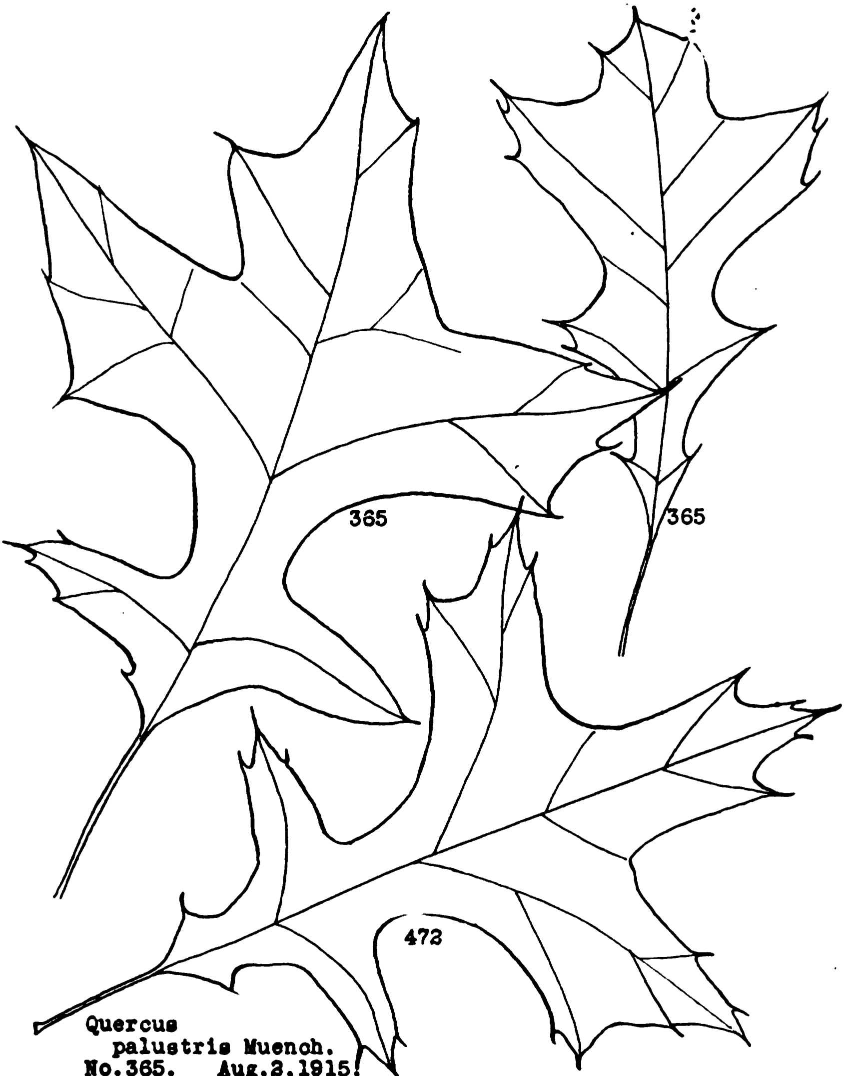
PLATE XIII.

Quercus bicolor Willd.

No.448. Sept.6.1915.

In Ward's thicket,1mi.
south of Reynolds,Ind.
Low,rich soil- swampy.
Tree 25'h.- 4"d.
Swamp White Oak.

PLATE XIV.



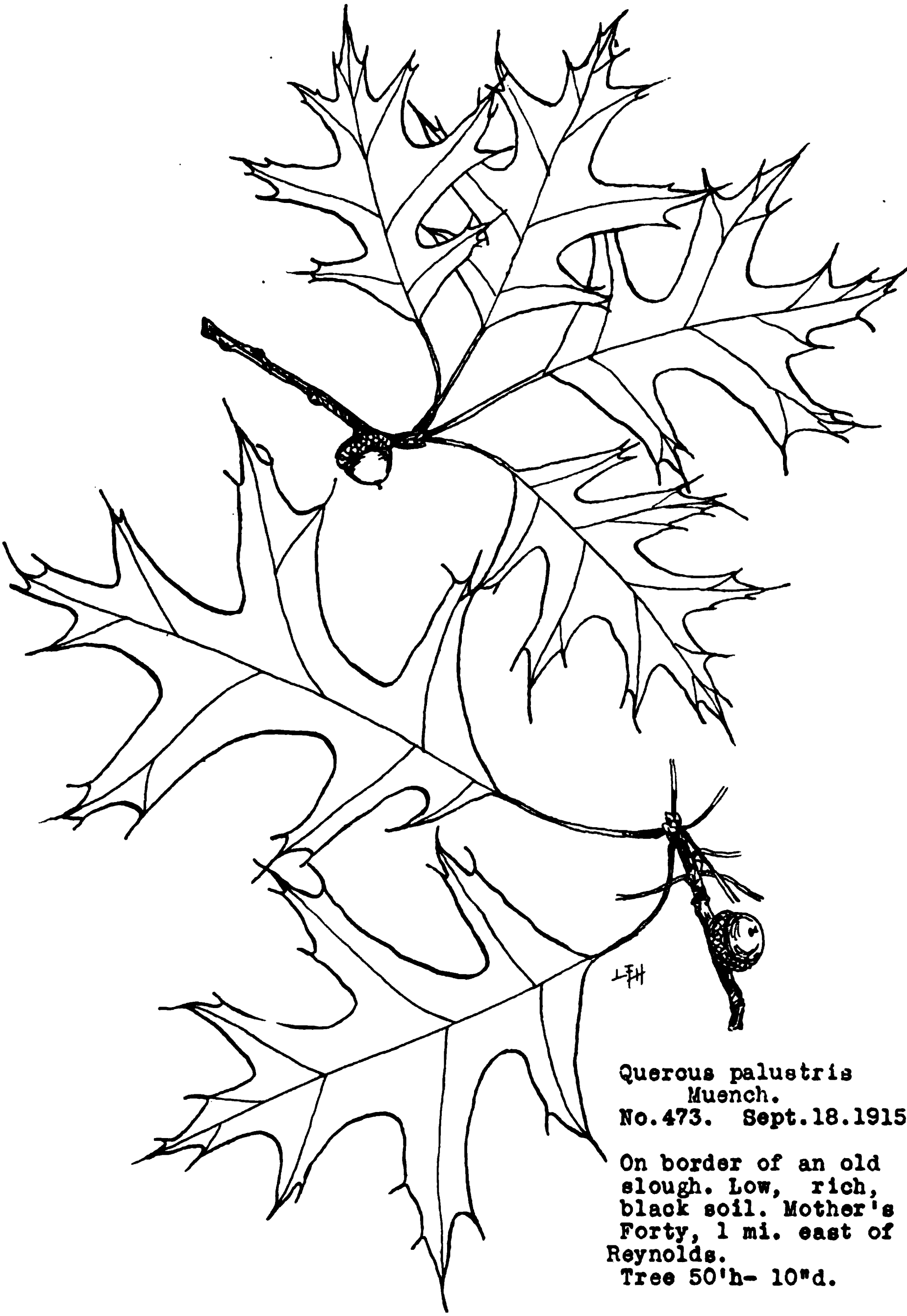
Quercus
palustris Muench.
No.365. Aug.2.1915.

In Ward's thicket, 1 mi.
south of Reynolds. Low,
moist, black soil. Swampy
Tree 40'h.- 7"d.
Determined by Sargent.

No.472. Sept.18.1915.

Bordering north and east
edge of an old slough, low,
rich, black soil. Mother's
Forty, 1 mi.s.of Reynolds.
Tree 40'h.- 8"d.
Determined by Sargent.

PLATE XIVi.



Querous palustris
Muench.
No.473. Sept.18.1915.

On border of an old slough. Low, rich, black soil. Mother's Forty, 1 mi. east of Reynolds.
Tree 50'h- 10"d.

PLATE XV.

Quercus palustris Muench.

No.251. Sept. 3. 1915.
Edge of a wooded sandridge,
low, moist, rich, black soil.
Bunnell's, east of Reynolds.
Tree 30'h.-6"d.

Plate XVI.

RANGE OF
Quercus alba L.
IN THE UNITED STATES AND INDIANA.

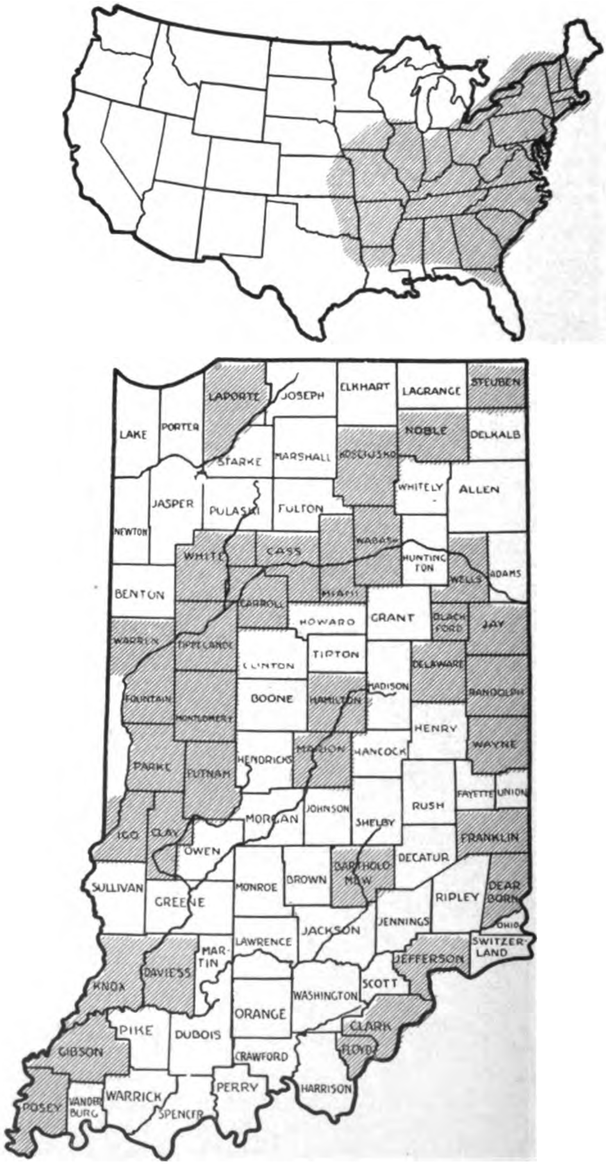


PLATE XVII.

RANGE OF
Quercus macrocarpa Michx.
IN THE UNITED STATES AND INDIANA.

PLATE XVIII.

RANGE OF
Quercus bicolor Willd.
IN THE UNITED STATES AND INDIANA.

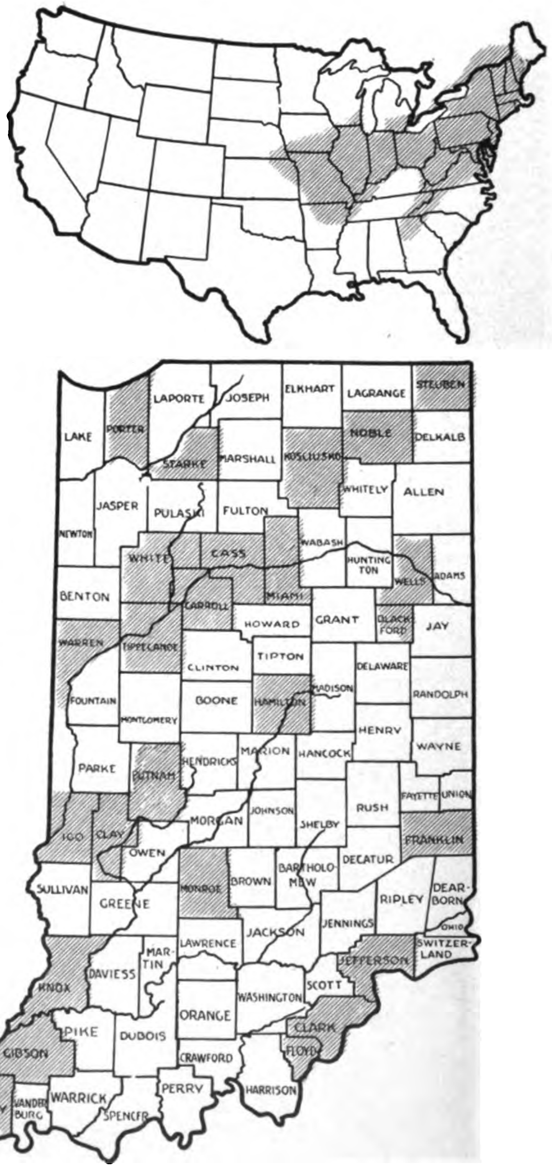


Plate XIX.

RANGE OF
Quercus imbricaria Michx.
IN THE UNITED STATES AND INDIANA.

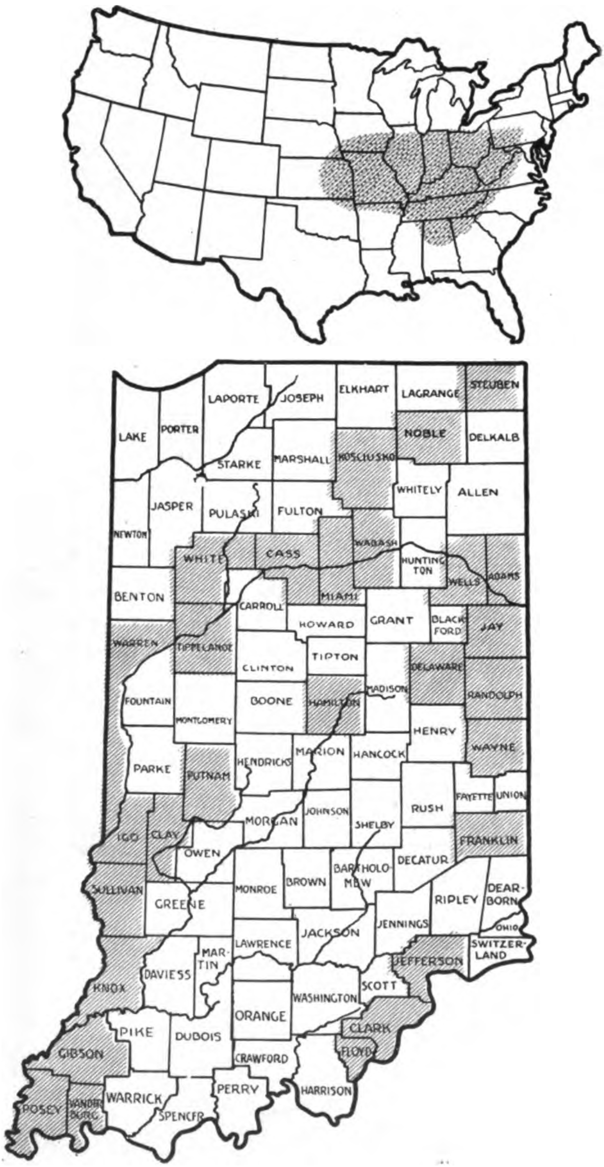


Plate XX.

RANGE OF
Quercus palustris Du Roi.
IN THE UNITED STATES AND INDIANA.

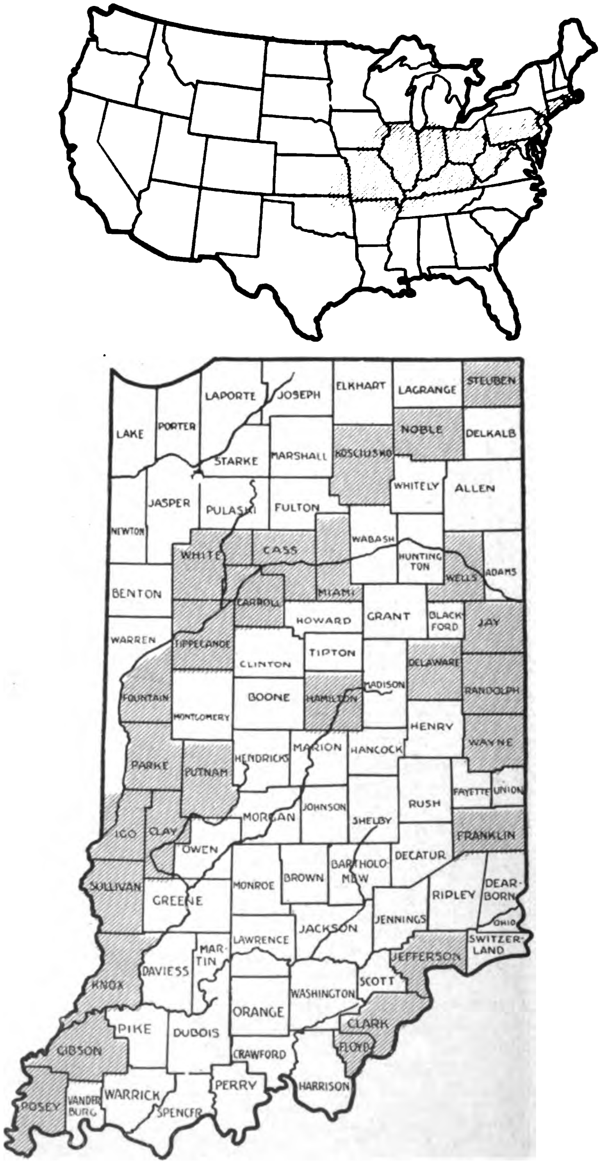


PLATE XXI.

RANGE OF
Quercus coccinea Muench.
IN THE UNITED STATES AND INDIANA.

The Black Oaks.

The Black Oaks form a difficult group in the identification of species. Numerically, the individuals in members of this group are many and well distributed over White County.

Quercus imbricaria Michx. Shingle Oak, Lea, Jack or Laurel Oak. (Hist. Chen. Am. 9 pl. 15, 16. 1801.)

This oak has been reported from 25 counties in Indiana and no doubt occurs in many others. It is the only entire-leaved oak in White County, and in our area it is a medium-sized tree. Specimens were found east of Monon, northwest of Reynolds, up in Princeton township, also southwest and east of Reynolds, at Norway, east of Chalmers near Big Creek, and east of Brookston. In a small grove just northwest of Brookston it forms an almost pure stand of fair-sized trees. It occurs in rich, moist soils or near the edges of low sand ridges.

Quercus palustris Muench. (and DuRoi?) Pin Oak, Swamp Oak, Swamp Spanish Oak. (Harbk 2:268 pl. 5-14. 1772.)

Q. palustris has been reported from 26 counties. It is said to be less frequent in the northern tier of counties. In White County it is frequent in low places, associated with other black oaks, but occupying the borders of former swamps rather than higher soil of the other nearby oaks. It is readily distinguished by its small acorns, small, thin, shallow cups, smoother bark than other indigenous oaks, wide divergent leaf lobes, and tardy pruning deflexed dead branches. (See pp. 421-423, 428.)

Quercus coccinea Wang. Scarlet Oak. (Amer. 44 pl. 4 f. 9. 1787.)

Though common throughout Indiana, the published records of this oak include but 16 counties. It is more or less common in White County. The fairly large top-shaped cup (2.5 cm. or more broad), with its glabrous, glossy, closely appressed brown scales or bracts about half enclosing the oblong-ovoid nut with its white kernel, makes this species readily recognizable.

Quercus valutina Lam. Black Oak, Quercitron, Yellow-bark Oak. (Encycl. 1:721. 1783. Q. tinctoria Bartram. Name only, 1791. Q. coccinea var. tinctoria A. Gray, 1867.)

Velutina is a very common species of oak in White County. It is

also rather common in the State, being reported from 25 counties. It is said to consist of several races, differing in leaf-lobing, amount of pubescence, and size of acorns. The large, somewhat loose bracts of the acorns with the upper ones rather squarrose or tips horizontally wrinkled are characteristic. Leaves which I have taken from sucker growth measure over a foot in length and over 9 inches in breadth. They are very variable—some are deeply lobed, others almost entire. The leaves on vigorous trees are also often comparatively large. The inner bark is a deep orange. Chewed bits of the twigs are said to give the saliva a yellowish discoloration in contradistinction to the Red Oak and the Scarlet Oak, if not as well for other black oaks. (See pp. 406, 408, 429.)

Quercus ellipsoidalis E. J. Hill. Hill's Oak. (Pin Oak, Yellow or Black Oak. Bot. Gaz. 27:204. 1899.)

There is no certainty how plentiful this oak is in White County. Sargent has verified a specimen taken about a mile northeast of Reynolds on a low sand ridge. The tree was about 30 feet high and 6 inches in diameter. "In Indiana it has been reported from Lake County only." Very likely it will be found to occur at points between White County and Lake Michigan.

Quercus rubra L. Red Oak. (Sp. pl. 996. 1753.)

This is the "largest and most valuable of the biennial oaks." It is distributed throughout the State. In White County it is rather restricted to the Tippecanoe area. The leaves are usually much less deeply lobed than those of the other black oaks. The acorn when mature is usually larger than the acorns of any other White County oak, except macrocarpa. (See p. 406.)

Quercus . . . ?

A rather peculiar specimen of oak was taken about four and one-fourth miles northeast of Brookston, in an oak forest on low, rich, black soil. Two such trees were growing just beside each other. The bark is close, almost black, and shallow fissured. These trees were about 45 feet high and 10 inches in diameter. Leaf specimens with twigs, buds and acorns were collected on September 7, 1915.

From the specimens and data at hand, at least three authorities have disagreed as to the status of this oak. All say it is a variable

PLATE XXII.

Quercus -------?

No. 455. Sept. 7. 1915.

Near road, in forest cn
low, rich, black soil,
$4\frac{1}{4}$ mi. N.E. of Brookston.
Trees (2) 45'h.- 10"d.
----See discussicn pp.52
and 53.

form and admit the difficulty of determination. It has been said to be a variable form of Q. texana Sarg., not Buckley ?, possibly synonymous with Q. Schneckii Brit. Q. borealis Michx., or Q. falcata Michx., or a hybrid of these two have been mentioned, as has also Q. velutina Lam.

My own idea coincides exactly with none of these. Q. borealis Michx. does not occur in the State, so far as known. Not a single reference to it is made in either Coulter's Catalogue or Deam's 1911 Report. Q. falcata Michx. has been reported from but three counties in the State, viz., Gibson, Posey and Fountain, which last is somewhat exceptional. Evidently the specimen under consideration is neither of these or could possibly be a hybrid of them. Since more or less doubt shrouds the texana-Schneckii determination from more than one standpoint, and since these are the same or different species according to different authors, I hesitate in applying either name, whether of the same or different species.

Q. velutina Lam. does not seem to be very conclusive.

The supposed typical leaves, fruit, etc., used in various keys for the same species many times, vary considerably. So in this case. The leaves in this instance compare very favorably with those shown for Q. rubra L., in Hough's Handbook of the Trees of the Northern States and Canada.

I have associated it most closely with Q. rubra L., being a rather variable form of that species or a hybrid of it with velutina or coccinea. I add this note from Hough's handbook: "Gray's Oak, Q. borealis Michx. f., (also Q. ambigua Michx. f.), a large tree, occasionally found from Ontario to Quebec to the mountains of North Carolina, bearing leaves like Q. rubra L., and fruit like Q. coccinea. It is considered by some a distinct species and by others, and probably more correctly, only an aberrant form of Q. rubra L."

3. The Hickories.

With a Revised List for the State.

The Hickories are very difficult of determination and authors are by no means agreed. If I may venture upon a suggestion, it seems to me that a more careful, thorough and extensive study *in the field* is

necessary before the genus can be satisfactorily divided into its species and varieties.

In the first place, the group has been favored with three genus names, viz., Juglans (L. 1753.); Hicoria (Raf.—1808.—Scoria Raf. 1808, Hicorius Raf. 1817, Hicoria Raf. 1836.); and Carya (Nutt. 1818.).

The walnuts and butternuts and our present hickories were all included under the term Juglans. The group was split up on the strength of whether the husk was dehiscent or not, and of course the so-called hickories emerged as a separate genus. Without going further into the historical side of the matter, both Hicoria and Carya as a genus name are commonly applied. I favor the term Hicoria, derived from the aboriginal or American Indian name with its apparent priority in print. Be this, however, as it may, the names and descriptions given to species are infinitely more troublesome.

The last 7th Edition, of Gray's Manual, describes eight species with all of these, possibly excepting Hicoria aquatica, within the borders of Indiana. Britton and Brown, new (2nd Ed.) Flora, contains 12 species, including but the same species as given in Gray for Indiana. Doubt shrouds several of these species as admitted in the texts.

Deam's 1911 Report lists seven species as occurring in Indiana. Except in name, this checks exactly for those given in Coulter's Catalogue. Very brief notes on the Indiana species are noted below, old and new records are given in a list following these notes.

1. *Hicoria Pecan (Marsh) Brit.* Pecan, Illinois Nut, Soft-shell Hickory. (See p. 436.)

This tree does not occur in White County. Its range as given in the 1911 Report is the lower Wabash and lower stretches of its tributaries. (See p. —.) Without doubt this species occurs in some as yet unreported counties. In a letter from Mr. Deam, Jan. 31, 1916, he says that H. Pecan extends up the Ohio Valley at least as far as Clark County. This species and the next are not difficult of determination.

2. *Hicoria cordiformis (Wang) Brit.* Bitter-nut, Swamp Hickory, Pignut, etc. (See p. 436.)

This species is said to occur throughout Indiana, being, however, nowhere abundant (Deam 1911 Report). In White County it is perhaps the most abundant in the central townships.

3. *Hicoria ovata (Mill) Brit.* Shagbark, Shellbark Hickory, etc. (See p. —.)

Common in all parts of Indiana. Common in White County in rich, moist soils or the edges of sand ridges. Sargent has split the species by designating two varieties. (See p. 437.)

(a) *Hicoria ovata fraxinifolia Sargent.*

As noted in the appended list, this variety occurs in three other counties besides White. Without attempting any description here, I simply add that Sargent verified a specimen for me, taken one and one-half miles southwest of Reynolds.

(b) *Hicoria ovata var. Nuttallii Sargent.*

This variety occurs in Indiana according to two determinations by Sargent. Specimens were taken in Dekalb County, south of Auburn. Leaflets 5. (Deam's Nos. 19, 291, 19, 293.)

4. *Hicoria laciniosa (Michx. f.) Sarg.* Big Shagbark, Kingnut, etc. (See p. 437.)

This species bears a close resemblance to the preceding species. At this time I am unable to define its distribution in White County other than to say that it occurs in Honey Creek Township. Rich soil, edges of sand ridges.

5. *Hicoria microcarpa (Nutt) Brit.* Small-fruited Hickory, Little Pig-nut or Shag-bark.

The habitat and range of this species has not been well studied (Deam 1911 Report). Sargent now calls the old microcarpa, ovalis—Carya ovalis Sarg.—or Hicoria ovalis, and has singled out no less than four varieties under the species. Since hickories are more or less abundant in White County this species with one or more of its varieties may be found there. I say this in view of my limited number of specimens and its reported occurrence in Tippecanoe County. (See list p. 437.)

6. *Hicoria alba (L) Brit.* White Hickory, Bull-Nut, Mocker Nut, etc.

Said to be rather rare in the northern part of the State. Locally more or less abundant in Honey Creek Township (White County), which with its low sand ridges is more suited to its drier situations.

7. *Hicoria glabra (Mill) Brit.* Black Hickory, Pignut, etc.

Sargent now styles this species porcina. I have taken no specimens

of it in White County, but owing to its wide distribution it seems reasonable to expect it there.

(a) *Hicoria glabra var. megacarpa Sargent.*

Another of Sargent's new varieties. "Franklin County, on high ground, west of Metamora. Bark tight, leaflets 5."

Without further comment I am permitted to add the following revised list for this very puzzling genus Hicoria. The determinations represent Sargent's latest efforts.

(List 6.)

REVISED LIST OF HICKORIES FOR INDIANA.

The determination of all the new records were made by Sargent. Specimens of these new records were collected by C. C. Deam, Prof. G. N. Hoffer and by myself, and are deposited in the Deam Herbarium, Bluffton, Ind.; Purdue Herbarium, Purdue University; Arnold Arboretum, Harvard University, and in my own herbarium. The chief change noted in the revised list is Sargent's recognition of seven new varieties.

1. Hicoria Pecan (Marsh) Brit. Pecan, Illinois Nut, Soft-shell Hickory. Juglans Pecan Marsh. 1785; Carya olivaeformis Nutt. 1818; Carya illinoiensis (Wang) K. Koch. ?; H. Pecan Brit. 1888.

Old Records: Franklin (Meyncke—from a cultivated tree?); Gibson (Schneck); Jefferson (Young); Knox (Thomas); Posey (Schneck), (Deam) and (Wright); Vigo (Blatchley).

No new records.

2. Hicoria cordiformis (Wang) Brit. Bitter-nut, Swamp Hickory, etc. J. alba minima Marsh. 1785; J. cordiformis Wang. 1787; C. amara Nutt. 1818; H. minima Brit. 1888; H. cordiformis Brit. 1908.

Old Records: Carroll (Thompson); Delaware, Jay, Randolph and Wayne (Phinney); Fountain (Brown); Franklin (Meyncke); Gibson and Posey (Schneck); Hamilton and Marion (Wilson); Knox (Ridgway); Noble (VanGorder); Parke (Hobbs); Steuben (Bradner); Vigo and Monroe (Blatchley); Wayne (Petry and Markle); Montgomery (Thompson); Posey (MacDougal and Wright); Putnam (Grimes); Tippecanoe (Coulter); Adams, Delaware, Hamilton, Jennings, Knox, Montgomery, Owen, Vermillion, Warren and Wells (Deam).

New Records: Allen, Bartholomew, Fountain, Franklin, Johnson, Knox, Switzerland (Deam and Hoffer); White (Heimlich).

3. Hicoria ovata (Mill) Brit. Shag-bark, Shell-bark Hickory, etc. J. ovata Mill. 1768; C. alba Nutt. 1818, not J. alba L.; H. ovata Brit. 1888.

Old Records: Cass and Tippecanoe (Coulter); Clark (Baird and Taylor); Delaware, Jay, Randolph and Wayne (Phinney); Franklin (Meyncke); Gibson (Schneck); Hamilton and Marion (Wilson); Knox (Ridgway) and (Thomas); Kosciusko (Clark) and (Scott); Posey (Schneck) and (MacDougal and Wright); Vigo (Blatchley); Wayne (Petry and Markle); Jefferson (Young); Monroe (Blatchley); Montgomery (Evans); Putnam (Grimes) and (MacDougal); Clark, Delaware, Hamilton, Jennings, Owen, Posey, Steuben and Wells (Deam).

New Records: Allen, Clark, Crawford, Franklin, Gibson, Jay, Knox, Owen, Pike, Steuben and Wells (Deam and Hoffer); White (Heimlich).

3. Hicoria ovata (Mill) Brit.

(a) var. fraxinifolia Sarg. 1916. Ash-leaved Shag-bark or Shell-bark Hickory.

No old records.

New Records: Daviess, Martin, Wells (Deam and Hoffer); White (Heimlich).

(b) var. Nuttallii Sarg. 1916.

No old records.

New Records: Dekalb (Deam).

4. Hicoria laciniosa (Michx. f.) Sarg. Big Shag-bark, King Nut, etc. C. sulcata Nutt. not J. sulcata Willd.; J. laciniosa Michx. f. 1810; H. sulcata Brit. 1888; H. laciniosa Sarg. 1894.

Old Records: Carroll (Thompson); Clark (Smith); Dearborn (Collins); Delaware, Jay, Randolph and Wayne (Phinney); Franklin (Meyncke); Gibson and Posey (Schneck); Jefferson (Coulter) and (Young); Knox (Ridgway); Kosciusko (Clark); Miami (Gorby); Noble (VanGorder); Parke (Hobbs); Putnam (Grimes); Steuben (Bradner); Tippecanoe (Coulter); Vigo (Blatchley); Harrison, Marion, Posey, Vermillion and Wells (Deam).

New Records: Allen, Bartholomew, Floyd, Gibson, Jay, Jefferson, Martin, Washington, Wells (Deam and Hoffer); White (Heimlich).

5. Hicoria ovalis. (C. ovalis Sarg. 1916.) H. microcarpa (Nutt) Brit. J. alba odorata Marsh. 1785; C. microcarpa Nutt. 1818; H. microcarpa Brit. 1888; H. glabra var. odorata Sarg. 1895. Small-fruited Hickory, Little Pignut or Shag-bark.

Old Records: Clark (Baird and Taylor); Delaware, Jay, Randolph and Wayne (Phinney); Franklin (Meyncke); Gibson (Ridgway) and (Schneck); Hamilton and Marion (Wilson); Jefferson (Coulter) and (Young); Knox (Ridgway); Kosciusko (Scott); Miami (Gorby); Posey (Schneck) and (MacDougal and Wright); Tippecanoe (Coulter); Laporte, Vermillion, Warren and Wells (Deam).

New Records: Allen, Bartholomew, Daviess, Floyd, Franklin, Gibson, Jay, Lagrange, Lawrence, Steuben, Sullivan, Washington, Wells (Deam and Hoffer).

5. Hicoria ovalis. (Carya ovalis Sarg.)

(a) var. odorata Sarg. 1916.

No old records.

New Records: Allen, Jefferson, Lagrange, Steuben and Wells (Deam and Hoffer).

(b) var. obovalis Sarg. 1916.

No old records.

New Records: Grant, Jackson, Lagrange, Steuben, Washington and Wells (Deam and Hoffer).

(c) var. obcordata Sarg. 1916.

No old records.

New Records: Grant, Lagrange, Porter and Wells (Deam and Hoffer).

H. ovalis. (C. ovalis Sarg.)

(d) var. ...... ??

No old records.

New Records: "These specimens seem to be a new variety," Sargent 1916. No name has been given. Specimens are from Knox and Gibson (Deam and Hoffer).

6. Hicoria alba (L) Brit. White-heart Hickory, Mocker-nut, Bull-nut, etc. J. alba L. 1753; J. tomentosa Lam. 1797; C. tomentosa Nutt. 1818; H. alba Brit. 1888.

Old Records: Cass (Benedict and Elrod); Clark (Baird and Taylor) and (Smith); Dearborn (Collins); Fountain (Meyncke); Gibson

and Posey (Schneck) and (Deam); Hamilton and Marion (Wilson); Jefferson (Coulter) and (Young); Knox (Ridgway); Kosciusko (Clark) and (Scott); Miami (Gorby); Vigo (Blatchley); Wabash (Benedict and Elrod); Tippecanoe (Coulter).

New Records: Daviess, Franklin, Harrison, Jackson, Jay, Jefferson, Knox, Lawrence, Sullivan, Washington (Deam and Hoffer); White (Heimlich).

7. Hicoria porcina. (C. porcina Sarg. 1916.) Pignut Hickory, Black Hickory. *Hicoria glabra* (Mill) Brit. J. glabra Mill. 1768; C. porcina Nutt. 1818; H. glabra Brit. 1888; H. glabra hirsuta Ashe. 1896.

Old Records: Cass and Wabash (Benedict and Elrod); Carroll (Thompson); Clark (Baird and Taylor) and (Smith); Dearborn (Collins); Delaware, Jay, Randolph and Wayne (Phinney); Franklin (Haymond) and (Meyncke); Gibson and Posey (Schneck); Hamilton and Marion (Wilson); Jay (McCaslin); Jefferson (Coulter) and (Young); Knox (Ridgway) and (Thomas); Noble (VanGorder); Parke (Hobbs); Putnam (Grimes) and (MacDougal); Steuben (Bradner); Tippecanoe (Coulter); Vigo (Blatchley); Delaware, Owen, Posey and Warren (Deam).

New Records: Crawford, Floyd, Franklin, Harrison, Lawrence, Martin, Sullivan (Deam and Hoffer).

7. Hicoria porcina. (Carya porcina Sarg.)

(a) var. megacarpa Sarg. 1916.

No old records.

New Records: Franklin (Deam).

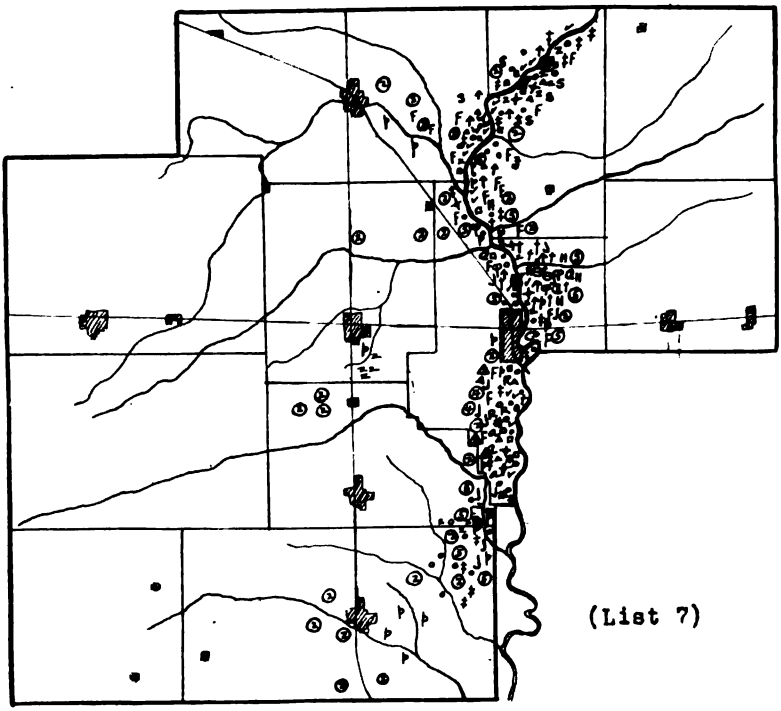
4. Trees Restricted to the Tippecanoe River Banks.

As indicated by the list and map on page 440, about half (23 out of 62) the species found in White County are totally or in some cases nearly exclusively confined to the Tippecanoe River banks. Some few of these are found at a distance from the river or the lower stretches of creeks. These include the Bur Oak, the Prickly Ash and others.

Though not restricted to the above area, the Red Cedar, the Black Walnut, Sassafras, and a few others, receive their best development in the vicinity of the Tippecanoe. The largest sassafras trees were noted near Buffalo, east bank of the river; the most abundant and largest

PLATE XXIII.

WHITE COUNTY.



(List 7)

...Trees Restricted to the Tippecanoe River Banks...

② Quercus macrocarpa Michx.
④ Muhlenbergii Engelm.
⑤ rubra L.
P Populus heterophylla L.
z Zanthoxylum americanum Mill.
A Acer nigrum Michx.
J Juglans cinerea L.
p Platanus occidentalis L.
• Liriodendron Tulipifera L.
× Celtis occidentalis L.
° Ostrya virginiana (Mill)Willd.
▲ Cercis canadensis L.
o Tilia americana L.
✓ Gleditsia triacanthos L.

\# Gymnocladus diocia(L)Koch.
R Robinia Pseudo-acasia L.
a Aesculus glabra Willd.
F Fagus grandifolia Ehrh.
↑ Ptelea trifoliata L.
† Staphyllea trifoliata L.
C Cornus florida L.
C alternifolia L.f.
† Asimina triloba (L)Dunal.
‡ Carpinus caroliniana L.
H Hamamelis virginiana L.
w Betula lutea Michx.
* Crataegus albicans Ashe ?

Cedars were seen south of Monticello, especially along the lower course of Big Creek. (See map, p. 451.)

Quercus macrocarpa Michx. See p. 409.

Quercus Muhlenbergii Engelm. See p. 411.

Quercus rubra L. See p. 431.

Populus heterophylla L. Swamp or Downy Poplar, River- or Swamp Cotton-wood., Balm-of-Gilead. In Indiana this tree is "rare and local, except in the lower Wabash bottoms." The published records of the distribution are as follows: Delaware, Jay, Randolph and Wayne (Phinney); Franklin (Meyncke); Gibson and Posey (Schneck); Hamilton (Doane); Jay (McCaslin); Knox (Ridgway); Miami (Gorby); Vigo (Blatchley); Blackford, Laporte, Posey, Wells (Deam).

I found specimens near the Carroll County line, five and three-fourths miles northeast of Brookston, in low, rich soil; trees 25 or more feet high and up to 6 inches in diameter. (See p. 454 for other species of Populus.)

Acer nigrum Michx. Black Sugar Maple, Black or Hard Maple. I cannot speak with certainty of the exact distribution of maples in the county. Species of this genus are very frequently used as shade trees and all have some escapes. Members of this genus were found in abundance near Buffalo and south along the Tippecanoe. Some trees are also to be found in oak forests of Honey Creek Township. A. nigrum was found about three miles south of Monticello. The group consisted of a number of large trees (70 feet high by 17 inches diameter) on a sandy, gravelly slope. (See other Maples p. 458.)

Juglans cinerea L. Butternut, White or Lemon Walnut, Oilnut. Reported from many counties, but said to occur in very sparing numbers in some. It is rather rare in White County and adheres to the banks of the Tippecanoe. Specimens were taken from fair-sized trees on high, rich, gravelly soil, east of Lowe's bridge, about four miles southwest of Buffalo. (See p. 454 for nigra.)

Platanus occidentalis L. Sycamore, Button-wood, Button-ball, Plane Tree. This is Indiana's distinctive tree. Found in all parts of the State, more or less frequent along streams or the borders of lakes. It has the distinction of being the largest deciduous tree in North America. (Tree at Worthington, Indiana, over 44 feet in circumference and 150 feet high.)

I have seen some comparatively large individuals along the Wabash up to the mouth of the Tippecanoe. It is found along the entire extent of the latter river through White County. It was also found in Honey Creek Township (Ward's thicket), near Spring Creek (J. P. Erickson farm) about three and one-half miles northeast of Brookston, and along Big Creek, four miles east of Chalmers.

Liriodendron tulipifera L. Tulip-tree, Yellow Poplar, Canoe-wood, Lime-tree, White-wood. The published lists for Indiana cover 41 counties. Rather rare in some localities. One of Indiana's largest and most useful trees. Not plentiful, but found along the entire length of the Tippecanoe through White County. "It is practically free from insect and fungous diseases" and is an excellent tree for re-enforcing the woodlot—a good shade tree.

The following trees are more or less common along the Tippecanoe and usually are not found far from the watercourse. Some of them have made their way along the creeks for several miles, notably Spring Creek, east of Brookston, Big Creek, Big Monon, and Pike Creek.

Celtis occidentalis L. Hackberry, etc.

Ostrya virginiana (Mill) Willd. Hop-hornbeam.

Carpinus caroliniana Walt. Am. Hornbeam, etc.

Cercis canadensis L. Red-bud, Judas-tree.

Tilia americana L. Linden, Basswood.

Gymnocladus diocia (L) K. Koch. Coffeenut-tree.

Aesculus glabra Willd. Ohio Buckeye.

Fagus grandifolia Ehrh. Beech.

Cornus florida L. Flowering Dogwood.

alternifolia L. f. Green Osier, etc.

Asimina triloba (L) Dunal. Pawpaw.

Ptelea trifoliata L. Hop-tree, Shrubby Trefoil.

Hamamelis virginiana L. Witch-hazel.

Staphylea trifoliata L. American Bladder-nut.

The last three of the above list are not included in Deam's 1911 Report. These are large shrubs or small trees. There are Ptelea at Norway, 15 feet high and 3 inches in diameter. The foliage when bruised has an unpleasant odor. The fruit is bitter and has been used as a substitute for hops. According to Coulter it is found in Jefferson,

Tippecanoe, Monroe, Vigo, Putnam, Gibson, Posey, Jay, Delaware, Randolph, Wayne, Clark, Franklin, Hamilton, Cass and Fayette Counties.

The Witch-hazel is interesting because of its flowering so late in the season (October to December). The bony seeds ripen in early spring and may be "shot" several yards from their capsules. Some shrubby specimens near Norway were eight feet or more high. Distribution given in Coulter's Catalogue: Kosciusko, Laporte, Jefferson, Tippecanoe, Clark, Noble, Delaware, Jay, Randolph, Wayne, Franklin, Monroe, Vigo, Cedar Lake, Hamilton, Putnam and Steuben.

The Bladder-nut, which may be a small tree in the south, is more nearly a large shrub in our area. Specimens seen at Norway were rather tall (perhaps 15 feet high). Distribution given in Coulter's Catalogue: Jefferson, Tippecanoe, Monroe, Vigo, Putnam, Gibson, Posey, Kosciusko, Hendricks, Decatur, Knox, St. Joseph, Hamilton, Marion, Steuben and Fayette.

Gleditsia triacanthos L. Honey Locust. This is a rather characteristic and imposing tree along the Tippecanoe. It is sometimes found along the lower portions of creeks.

Robinia pseudo-acasia L. Common Black Locust. This locust was noted several miles south of Monticello and also near Lowe's bridge. It is cultivated in all parts of the county and escapes are occasionally found.

Betula lutea Michx. Yellow Birch. This species has been confused with Betula lenta, which, according to Deam, does not occur in our area. In Indiana it is rare and local. It has not been reported south of Miami County except in Crawford County, associated with the laurel (Kalmia latifolia), which is the only station of the latter in the State, except possibly another record for Floyd County.

Specimens were taken from two trees about two miles south of Buffalo near the water's edge of the river. These were thought to be different species at first, but they are likely both lutea. It is certain that one is lutea and the other will likely be found to be so when fresh material is available. A mere guess at the height of these trees would place them about 40 feet high. They were associated with maples, ashes, sycamores and honey-locusts.

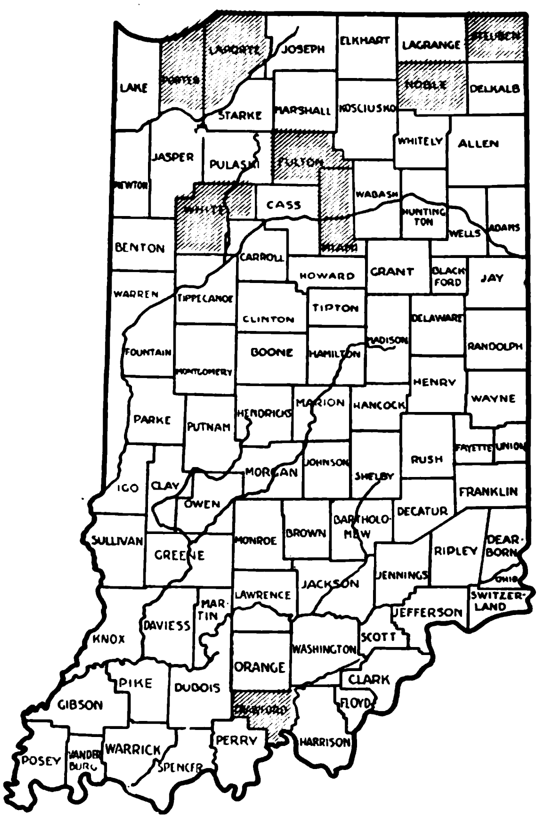
Zanthoxylum americanum Mill. Prickly Ash, Toothache Tree, An-

PLATE XXIV.

RANGE OF

Betula lutea Michx.

IN THE UNITED STATES AND INDIANA.



gelica Tree, etc. This species is conspicuous along some parts of the Tippecanoe (Norway and Buffalo). Several trees were found in Ward's thicket, about a mile south of Reynolds, and also along Big Creek, four miles east of Chalmers. It is variously called a small tree or a large shrub and is not included in the 1911 Report. Some of the specimens found were about 10 feet high and 3 inches in diameter.

In Coulter's Catalogue it is reported from Posey, Vigo, Cass, Kosciusko, Steuben, Jefferson, Randolph, Franklin, Shelby and a dozen other counties.

The Thorns constitute one of the most puzzling genera in the plant kingdom. More field work is necessary before statements of ranges and abundance of each species in White County is possible. It is likely that more species occur in the county than is given here. (See p. 457.)

Crataegus pruinosa (Wendl) K. Koch. Waxy-fruited Thorn. (C. populifolia Ell. 1821; not Walt.; Mespilus pruinosa Wendl. 1823; C. pruinosa K. Koch. 1853; C. Porteri Brit. 1900. Specimens of this thorn were obtained east of Norway across the river in the vicinity of the mouth of Pike Creek. A number of thorn trees are present in this locality, this species being perhaps locally abundant. On gravelly soil, low river bank. Trees 12 feet high, 4 inches in diameter. Determined by Sargent.

Deam says this thorn is well distributed in Indiana. Specimens have been seen from the following counties: Decatur, Delaware, Gibson, Hamilton, Madison, Steuben, Warren, Wells (Deam); Putnam (Grimes).

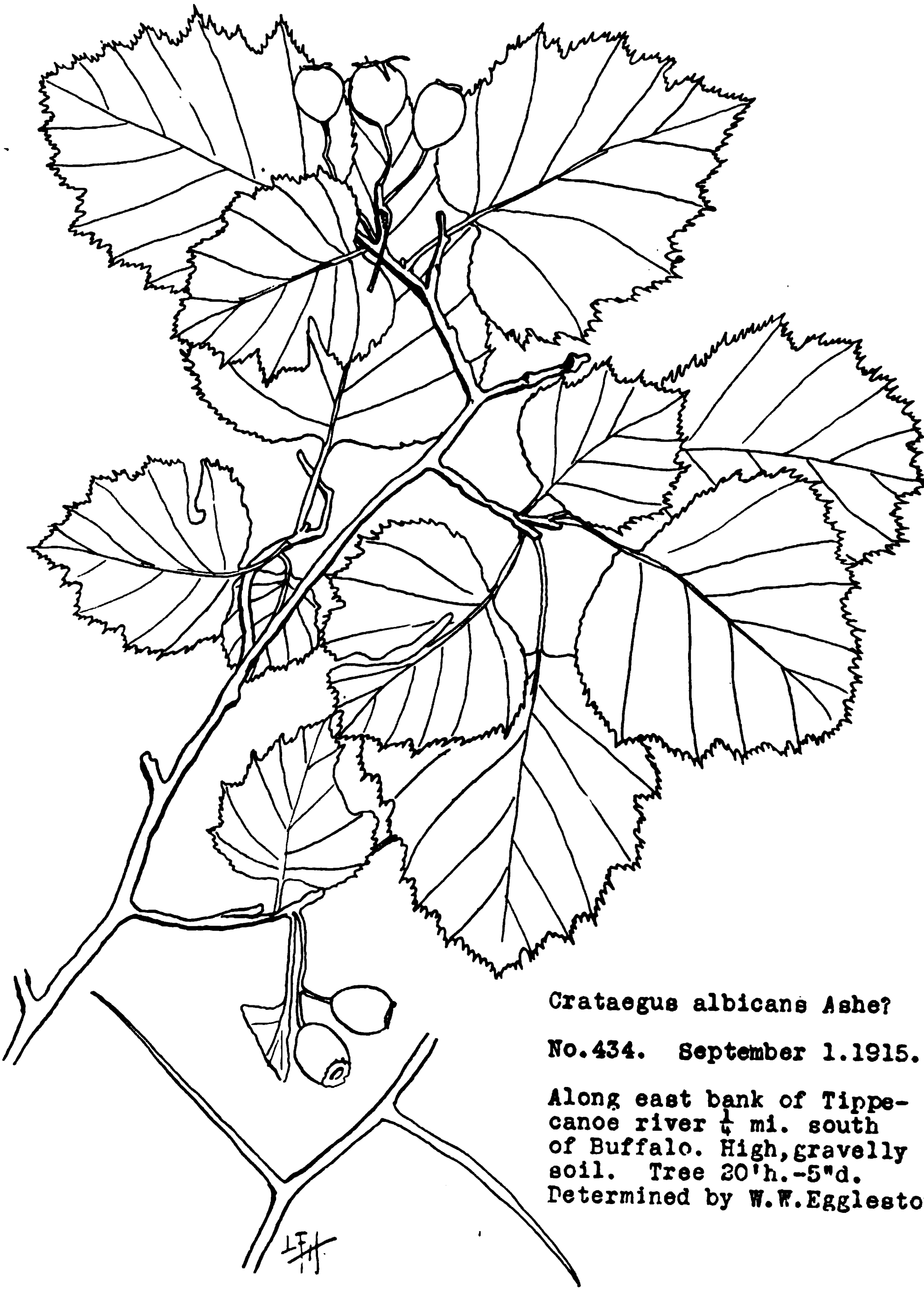
Crataegus albicans Ashe? Tatnall's Thorn. C. albicans Ashe 1901; C. Tatnalliana Sarg. Feb. 1903; C. polita Sarg. Apr. 1903. I quote the following from a letter from W. W. Eggleston: "Your specimen of Crataegus sent me . . . . is received. It belongs in the Coccineae and seems to be C. albicans Ashe? More complete material showing the leaves on the vegetative shoots is desirable to be sure of the identification, for with this material I could not be quite sure that it is not C. coccinea L." Britton and Brown, 2nd Ed., makes the following distinction between the two species:

Leaves on vegetative shoots cuneate, C. coccinea.

Leaves on vegetative shoots cordate, C. albicans.

It will be noted that C. albicans has not been reported as occurring in the State. Its general range is given as "Western New England to

PLATE XXV.



Crataegus albicans Ashe?

No. 434. September 1. 1915.

Along east bank of Tippecanoe river $\frac{1}{4}$ mi. south of Buffalo. High, gravelly soil. Tree 20'h.-5"d. Determined by W. W. Eggleston.

southern Michigan, south to Delaware and in the mountains to northeastern Tennessee."

C. coccinea has the following record for the State: Floyd (Deam); Noble (VanGorder); Steuben (Deam).

The specimen taken was from a lone tree, one-fourth mile south of Buffalo on a high, gravelly river-bank. Tree 20 feet high, 5 inches in diameter. No. 343. September 1, 1915. Additional material is not to be had before the completion of this thesis and so the exact determination must be deferred till some later date. (See p. 457 for other Haws, also p. 449.)

Thus the Tippecanoe River has some 28 species clinging closely to its banks, besides claiming specimens of all other species in White County, except possibly one or two species of willows, Quercus ellipsoidalis and Malus ioensis.

5. Report of a New Species and a New Variety for the State.

Salix missouriensis Bebb. Missouri or Diamond Willow, Heart-leaved Willow. 1895.

S. cordata Muhl. 1803; S. angustata Pursh. 1814; S. cordata angustata (Pursh) Anders. 1867; S. acutidens Rydb. 1901.

The above are the synonyms given in Britton and Brown, 2nd Ed., with S. cordata Muhl. preferred.

Sargent, who determined my specimen, called it S. missouriensis.

In Gray's Manual, 7th Ed., cordata and missouriensis are treated as separate species, the last, however, with this note: "A poorly understood tree, said to flower earlier than S. cordata; perhaps a variety (var. vestita Anders.) of that species."

In Hough's Handbook of the Trees of the Northern States and Canada, the Missouri Willow is given as Salix missouriensis *Muehl.*, with the synonym of S. cordata var. vestita Sarg.

In the face of all the above, hybridization is mentioned by each of the contending authors. (See ranges given on map, p. 450.)

This willow has hitherto been unreported for the State except that S. cordata Muhl. and S. cordata angustata (Pursh) Anders. are reported in Coulter's Catalogue, the former with the record: "In a few counties in rather sparing numbers, growing in low, moist soils. More abundant southward. Flowers in April and May. Putnam (MacDougal); Vigo

PLATE XXVI.

Salix missouriensis Bebb.

No. 374. August 4. 1915.

Along road ditch, near
Pennsylvania railroad,
$1\frac{3}{4}$ mi. east of Reynolds.
Low, wet, rich soil.
Bushes about 10 ft. high.
Determined by Sargent.

(Blatchley); Tippecanoe (Coulter)." The last mentioned has this record: "In wet soil in the northern part of the State. Flowers from April to May. Steuben (Bradner)."

I have seen no specimens of the above for comparison. The report of missouriensis may or may not be new to the State. Owing to the hybridizing character of the willows and the difficulty of separation, much additional work is necessary before the status of this genus is settled satisfactorily.

The specimens I found in White County consisted of a small group of shrubby growth not more than 10 feet high, one and three-fourths miles east of Reynolds, near the Pennsylvania Railroad, growing along a road ditch in low, wet, rich, black soil. Specimens with fruiting parts were taken on August 4, 1915. Stems with catkins were also collected on April 16, 1916.

Salix longifolia var. *argophylla Sarg.* 1916. By the courtesy of Mr. Deam, I am allowed to report this new variety of willow for the State. A specimen was taken by Mr. Deam "on the bank of the big dredge ditch (Little Monon Creek), meeting the railway from the south, about a mile east of Seafield, White County. Determined by Sargent."

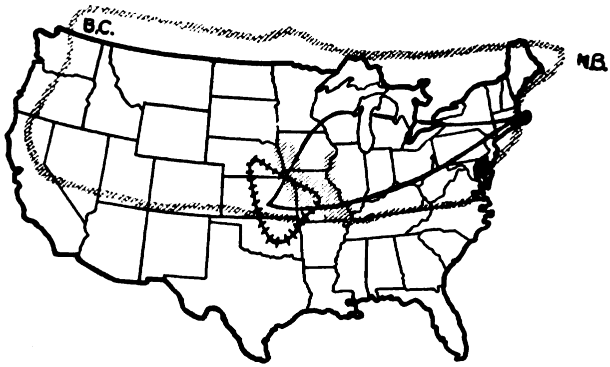
I took specimens of S. longifolia Muhl., determined by Sargent as S. fluviatilis, about three and one-half miles north of the above place, along the same creek, and also about three miles northeast of this place on the banks of the Hoagland ditch.

The latest floras do not include the above variety. (See S. interior Rowlee, p. 452.) (S. sessifolia Nutt., S. argophylla Nutt., S. fluviatilis argophylla Sarg.)

Crataegus albicans Ashe? Tatnall's Thorn. If the above determination can be verified, it will increase the already long list of thorns for the State. As has been indicated on p. 445, Eggleston favors this determination with the material at hand. If Salix missouriensis does not prove to be new to the State this species may be. (See p. 446.)

PLATE XXVII.

RANGE OF
Salix Missouriensis Bebb.
IN THE UNITED STATES AND INDIANA.



BRITTON AND BROWN - 2nd Edi.

Salix cordata Muhl.
S. angustata Pursh.
S. cordata angustata Anders.
S. missouriensis Bebb.
S. acutidens Rydb.

HOUGH.

U.S. Salix Missouriensis Muehl.
S. cordata var. vestita Anders.

GRAY - 7th Edi.

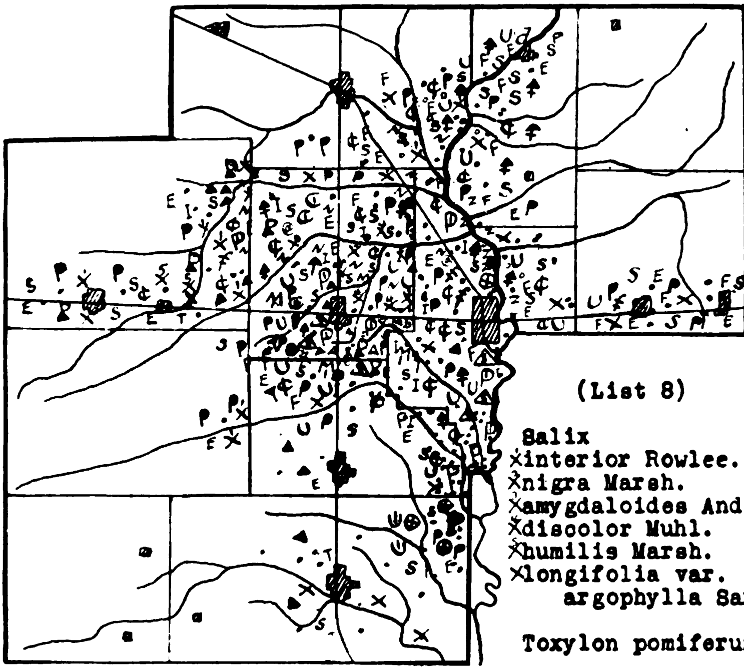
Ind. Salix missouriensis Bebb.
S. cordata - var. vestita Anders?
Salix cordata Muhl.
var. myricoides (Muhl) Carey.

COULTER.

Salix cordata Muhl.
Salix cordata angustata (Pursh) Anders.

PLATE XXVIII.

WHITE COUNTY.



(List 8)

Salix
x interior Rowlee.
x nigra Marsh.
x amygdaloides Anders.
x discolor Muhl.
x humilis Marsh.
x longifolia var. argophylla Sarg.

Toxylon pomiferum Raf.

General Distribution of Trees over the County -- Omitting the OAKS and HICKORIES, and also those Species more Typically Restricted to the Tippecanoe.

d Amelanchier canadensis(L)Med.	¢ Corylus americana Walt.
P Populus alba L.	⊗ Morus rubra L.
grandidentata Michx.	U Ulmus americana L.
tremuloides Michx.	U fulva Michx.
deltoides Marsh.	A Prunus americana Marsh.
S Sassafras sassafras (L)Karst.	• serotina Ehrh.
M Malus malus (L) Britton.	@ Cephalanthus occidentalis L.
M ioensis(Wood)Britton.	C Cornus femina Mill.
N Nyssa sylvatica Marsh.	C stolonifera Michx.
Crataegus Crus-galli L.	Z Zanthoxylum americanum Marsh.
Calpodendron(Ehrh)Medic.	E Sambucus canadensis L.
I Ilex verticillata(L)A.Gray.	▲ Rhus copallina L.
A Acer saccharinum L.	hirta Sudw.
saccharum Marsh.	glabra L.
negundo L.	• Juniperus virginiana L.
F Fraxinus americana L.	f Viburnam prunifolium L.
pennsylvanicaMarsh.	f Lentago L.

6. Species Generally Distributed Over the County.

Salix interior Rowlee. Sandbar Willow. The willow referred to as the Sandbar willow of various authors suffers various scientific names without much apparent agreement. The record in Britton and Brown is as follows: S. longifolia Muhl. 1803; not Lam. 1778; S. interior Rowlee 1900; S. linearifolia Rydb. 1901. Has been confused with S. fluviatilis Nutt. (S. Wheeleri (Rowlee) Rydb. . . . . from N. B. to Ill., differs in having the leaves permanently silky.). Gray's 7th Ed. says that S. longifolia Muhl. is the Sandbar willow. Synonym, S. interior Rowlee; S. fluviatilis auth., not Nutt. Hough gives S. fluviatilis Nutt. as the Sandbar willow with the synonym of S. longifolia Muhl.

Thus the trials and patience of the amateur, and I should also include the expert, are once more exemplified, if not sorely pressed. One wonders in so many cases if no agreement ever will result. At any rate, the species which answers the description of S. interior Rowlee is abundant along the streams of White County.

This species is not given in the 1911 Report. In Coulter's Catalogue the record is as follows: Salix fluviatilis Nutt., Syn. S. longifolia Muhl. Tippecanoe (Cunningham); Putnam (MacDougal); Vigo (Blatchley); Jefferson (J. M. Coulter); Clark (Baird and Taylor).

Due perhaps chiefly to their tendency to hybridize, the willows are admittedly difficult of determination. The remaining forms considered as occurring in White County seem to be less confusing.

Salix nigra Marsh. Black Willow. This willow is more or less abundant in White County. Specimens were taken from Honey Creek Township. Its range is more than the total eastern half of the United States.

Salix amygdaloides Anders. Peach-leaved Willow. Although having a large range in North America, from Quebec through Saskatchewan to British Columbia, and through northern Kentucky to the Rio Grande in New Mexico, along the mountains to Oregon and Washington, this species is not mentioned in Coulter's Catalogue, and in the 1911 Report the published record is but from one county, Kosciusko (Scott), with the then new record of a specimen each taken in Lake County by Umbach and Deam. Distribution in White County uncertain, specimen taken from Honey Creek Township.

PLATE XXIX.

RANGE OF

Salix amygdaloides Anders.

IN THE UNITED STATES AND INDIANA.

Salix discolor Muhl. Glaucous Willow. This form has been omitted from the 1911 Report. In Coulter's Catalogue it is reported from Tippecanoe (Cunnington); Jefferson (Barnes); Vigo (Blatchley); Kosciusko (Coulter); Clark (Baird and Taylor); Gibson and Posey (Schneck); Knox (Spillman); Hamilton (Wilson); Steuben (Bradner). It is more or less abundant in White County. Specimens were taken in Monon and Honey Creek Townships.

Salix humilis Marsh. Prairie Willow. This willow is not included in the 1911 Report, nor is it mentioned in Hough's Handbook of the Trees of the Northern States and Canada. The range for Indiana as given in Coulter's Catalogue is as follows: Laporte (Barnes); Putnam (MacDougal); Vigo (Blatchley); Tippecanoe (Coulter); Hamilton (Wilson); Steuben (Bradner).

In this, as in many other instances, the attention is drawn to the number of well-worked counties. It occurs in Honey Creek Township and is very likely in other townships.

Populus tremuloides Michx. American Aspen, Quaking Asp or Aspen, 1803. The Quaking Aspen is a very familiar tree in White County. Very abundant in low, wet places. Sometimes found growing with the Cottonwood.

Populus deltoides Marsh. Cottonwood, Necklace Poplar. (P. carolinensis Moench. 1785; P. monilifera Ait. 1789; P. angulata Ait. 1789.) This is a much larger tree than the Quaking Aspen. Common throughout the county. Said to consist of several races.

Populus grandidentata Michx. Large-toothed Aspen. Scattered throughout the county in low, rich soils, or near the edges of sand ridges.

Populus alba L. White or Silver-leaf Poplar. Introduced from Europe. Escapes in all parts of the State, although the published records are meagre. Escapes in several places in White County. Specimens were taken from trees along Big Creek about four and one-fourth miles east of Chalmers.

For Populus heterophylla see p. 441. The above species of this genus are arranged in the order of their frequency in White County.

Juglans nigra L. Black Walnut. Common throughout the State. Found along the Tippecanoe River and also some distance from its banks in locally abundant numbers. Cultivated throughout the county. (See p. 464.) (J. cinerea, see p. 441.)

Corylus americana Walt. Hazelnut, Filbert. The hazel sometimes becomes a rather large shrub. It is very abundant in White County, as well as throughout the State.

Ulmus americana L. American or White Elm. Reported from 29 counties in the State. Of general distribution in White County along with—

Ulmus fulva Michx. Slippery, Red, or Moose Elm. Said to be in more sparing numbers in the State than the preceding, but nevertheless reported from an extra county. Not abundant, merely local in White County.

Morus rubra L. Red Mulberry. Isolated trees or very small groups in various parts of the county. Along the lower stretches of Spring Creek it is associated with elms, hop-hornbeams, etc.

Toxylon pomiferum Raf. Hedge, Osage Orange. The natural range of this species covers only the adjacent borders of Texas, Oklahoma, Indian Territory, Arkansas and Louisiana, or from Missouri and Kansas south to Texas. It has been cultivated over a considerable part of the country and escapes are more or less frequent. Escapes in Indiana are given for Decatur (Ballard); Franklin (Meyncke); Hamilton (Wilson); Jefferson (J. M. Coulter); Tippecanoe (Thompson); Vigo (Blatchley); Montgomery (Evans); Putnam (Grimes); Knox (Deam).

In various parts of White County it has a tendency to spread away from the fence rows. Reports of isolated trees occurring along the Tippecanoe are likely, but at this time must be given as uncertain.

Sassafras variifolium (L) Karst. Sassafras. Although but one species of Sassafras is recognized, two forms are known and attention to the difference is here noted. "One is known as White Sassafras, which is nearly all sap wood, and the bark of the roots is white. In contact with the soil the wood soon rots. The other is known as the Red Sassafras. The bark of the roots and the greater part of the wood is red, and is durable in contact with the soil."* Both forms are common in White County. The larger trees are found along the Tippecanoe near Buffalo.

Malus malus (L) Brit. Apple. The apple tree has escaped in various parts of White County and large trees are sometimes found.

* Deam 1911 Report, page 238.

PLATE XXX.

RANGE OF

Malus ioensis (Wood) Britton.

IN THE UNITED STATES AND INDIANA.

It is not included in the 1911 Report nor in Coulter's Catalogue. Why should it not receive the same treatment as other escapes? (Toxylon, Populus alba, Ailanthus, etc.)

Malus ioensis (Wood) Brit. Western Crab Apple. This is a western form, as the range map shows (p. 456). A broad-leaf and a narrow-leaf form are described in the 1911 Report. Both forms occur in White County. Specimens were taken from trees on a low sand ridge about one mile northeast of Reynolds. (See Deam 1911 Report, pp. 248 and 250.)

Amelanchier canadensis (L) Medic. Service-berry, June-berry, May or Sand-cherry. The June-berry remains a small tree in White County and is met with in very sparing numbers in different parts of the county. The specimens taken were somewhat variable, but it is thought all belong to the same species.

Crataegus crus-galli L. Cockspur Thorn, Newcastle Thorn. A small tree, said to be well distributed in Indiana, but with reports only from the following counties: Decatur (Mrs. C. C. Deam); Knox and Gibson (Schneck); Owen (Grimes); Vigo (Blatchley); Crawford, Jackson, Lawrence, Posey and Wells (Deam). More or less abundant along the Tippecanoe and in sparing numbers over the county.

Crataegus calpodendron (Ehrh) Med. Pear Thorn, Pear or Red Haw. (C. Crus-galli Mill. not L.; C. tomentosa DuRoi, not L.; C. Chapmani Ashe; etc.). Specimens of this thorn were found in Honey Creek, Monon and Union Townships. It is likely to be found in others. Specimens have been examined from the following counties: Putnam (Grimes); Marion, Posey and Wells (Deam).

The national as well as the State distribution of the thorns must be as yet rather uncertain. For notes on other White County thorns see pp. 445, 446.

Prunus americana Marsh. Wild Red Plum. Found throughout Indiana and reported from thirty-four counties. Single trees and small clumps in various parts of White County.

Prunus serotina Ehr. Wild (Black) Cherry. Common in all parts of the State. Very common in White County. The wood, bark and fruit are each of some economic importance.

Zanthoxylum americanum Mill. Prickly Ash. Toothache Tree. According to Coulter's Catalogue, "A small tree, sometimes reduced to

a shrub, which is generally distributed over the State." In White County it is most commonly found along the Tippecanoe. It was also noted in Ward's thicket in Honey Creek Township and along the lower part of Big Creek.

Rhus hirta (L) Sudw. Staghorn Sumac. (Rhus typhina L.) Said to be frequent but not especially abundant in any of its stations in various parts of the State. Rather abundant in some places of White County. Perhaps the most common sumac in the county.

Rhus glabra L. Smooth Upland or Scarlet Sumac. This sumac is similar to the preceding, but is glabrous throughout. Reported as being more common in the State than the above species. Well distributed but not so abundant in White County.

Rhus copallina L. Dwarf Black or Mountain Sumac. Upland Sumac. This form becomes a distinct small tree in White County. Noted mostly in Honey Creek Township.

The above three species are rich in tanin and are extensively used for tanning. None of them are poisonous, but the last two should be handled with care by persons with thin, sensitive skins. Another species of rhus, *R. Toxicodendron L.* (or R. radicans L.), the Poison Ivy, which grows both as a climbing vine or as a low shrub, is very poisonous. The berries are not poisonous and are largely eaten by birds. The poison ivy is commonly met with in different parts of the county.

Ilex verticillata (L) A. Gray. Virginia Winter-berry, Black Alder, Fever-bush. This is a shrub, attaining a height of 6 feet or more. Abundant in White County as well as in the State.

Acer saccharinum L. Soft, Silver, or White Maple. Reported from many counties. In White County most abundant near the Tippecanoe. A few large trees (60 to 70 feet high) are to be found in Fisher's Woods one mile south of Reynolds. Extensively used as a shade tree.

Acer saccharum Marsh. Sugar, Rock, or Hard Maple. Reported as frequent to common in all parts of Indiana. Of uncertain distribution in White County. Specimen from a small tree about four and one-fourth miles southeast of Chalmers along a small stream near the banks of Big Creek.

Acer negundo L. Box Elder, Ash-leaved or Cut-leaved Maple. Rare east of the Appalachians, rare to infrequent in northern Indiana. Used to some extent as a shade tree in White County. Rather inferior tree,

escapes easily. Specimens were found along the Tippecanoe, near Tioga, and also near Buffalo. Its natural migration into White County seems doubtful. Escapes were also noted in Honey Creek Township. (For notes on A. nigrum see p. 441.)

Nyssa sylvatica Marsh. Gum, Black or Sour Gum, Pepperidge. Well distributed in Indiana. Frequent to common in White County. A tall tree attaining a greater diameter than most trees in the county. The leaves are variable and are not to be mistaken for those of N. aquatica L., which has been off the list of Indiana trees. (See Deam 1911 Report p. 93, also pp. 321-323.)

Cornus stolonifera Michx. Red Osier, Kinnikinnik. Absent from the extreme southern counties, but abundant in the northern counties (Coulter's Catalogue). Found in all parts of White County. Readily distinguished by its bright purple twigs at some distance. Sometimes a rather tall, thick-stemmed shrub.

Cornus femina Mill. Panicled Cornel or Dogwood. White-fruited Dogwood. (C. paniculata L'Her. 1788; C. caudissima Marsh. 1785; not Mill. 1768.) Reported in Coulter's Catalogue from various parts of the State. Taller in White County than is noted in the preceding reference (3 to 6 feet high). Britton and Brown give it a height of 6 to 15 feet. Many specimens in White County are between these figures. Often found in great clumps in low, wet places in woods or in the open. The fruit is white and usually abundant. (For other Cornels see p. 442.)

Fraxinus americana L. White Ash, Gray Ash. This ash is very common along the Tippecanoe and is distributed over the county generally. Marked differences in the twigs of older and younger trees and other minor differences were noted. Frequent to common in all parts of the State.

Fraxinus pennsylvanica Marsh. Curiously enough this ash is variously known as the White, Gray, Black, Green, Red, Blue, Water, Swamp, or River Ash. It also bears at least three other scientific names, (F. pubescens Lam.; F. lanceolata Borck.; F. viridis Michx. f.) Its leaves, and especially its fruit, are very variable. (See Deam 1911 Report, illustrations p. 334.) More or less frequent in all parts of Indiana, but reported from only twenty-two counties. Its distribution for White County is not determined; specimens were taken from Honey Creek Township, southwest of Reynolds.

PLATE XXXI.

RANGE OF

Viburnam Lentago L.

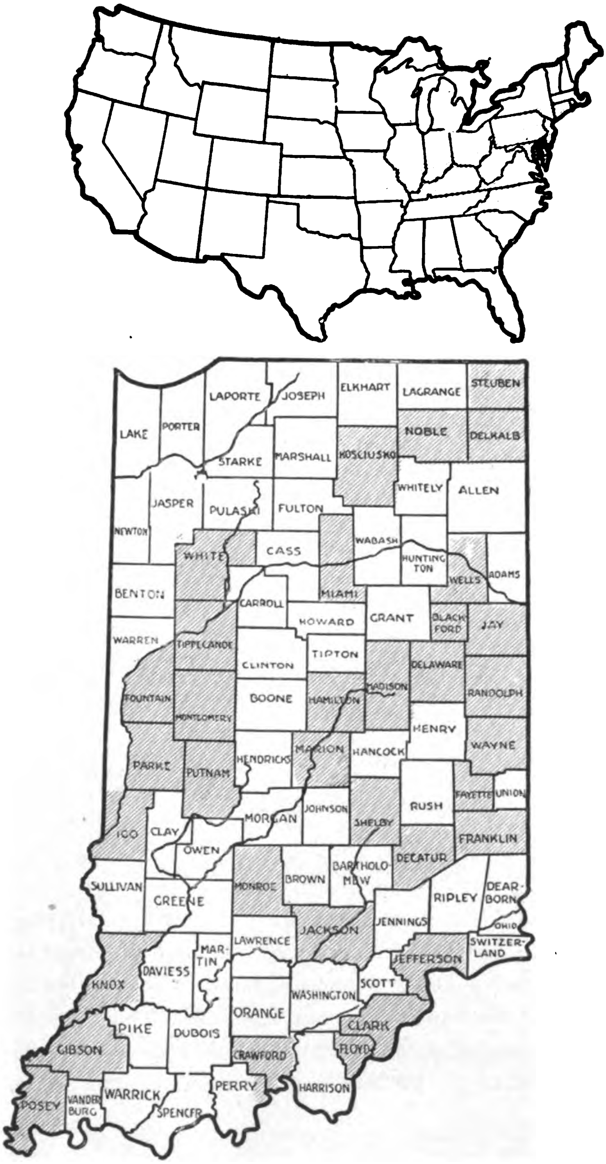
IN THE UNITED STATES AND INDIANA.

PLATE XXXII.

RANGE OF

Viburnam prunifolium L.

IN THE UNITED STATES AND INDIANA.



The above two species were the only ones of this genus found in the county. This was a disappointment, since F. quadrangulata Michx., and F. nigra Marsh., are reported from Cass, Tippecanoe and a number of other counties. Both of these may occur in the county.

Cephalanthus occidentalis L. Button-bush, Honey-balls, Pond-Dogwood, etc. An abundant shrub or small tree (20 feet high) in all parts of the State (Coulter). Found in all parts of White County, though not so abundant as a medium-sized shrub. Easily recognized by its flowers.

Viburnam lentago L. Sheep-berry, Nanny-berry, Black Haw, etc.

Viburnam prunifolium L. Black Haw, Stag-bush, etc. It is somewhat surprising to find that the latter, having a much smaller range in the United States, should be reported from so many more counties in Indiana than the former with its very great range. (See range maps pp. 460 and 461.) In so far as I have been able to discover, the former is far more plentiful in White County, sometimes forming great patches on cut-over areas. The fruit of both is sweet and edible.

Sambucus canadensis L. Elder-berry. Abundant throughout the State in various situations (Coulter). Common in White County. The flowers and fruit have strong medicinal properties. (Brit. & Br.)

Juniperus virginiana L. Red Cedar, Juniper, etc. This is the only native evergreen of the county. Reported from various counties with different degrees of abundance. Well distributed in White County, reaching its best development along the Tippecanoe. Many trees, some of fair size, were found about two miles up from the mouth of Big Creek.

(For other species distributed more or less generally over the county see The Oaks, pp. 405-433, and the Hickories, pp. 433-436.)

V. ECONOMIC USES.

The original forest of White County must have been extensive and must have exhibited a high-grade quality of timber quite generally. For several decades after 1830 there were numerous sawmills operating in various parts of the county. Some of the pits, wells or other vestiges of these mills are still to be seen, though perhaps the location of most of them is a matter of speculation.

The results of individual inquiry concerning the specific activities of these early sawmills were very meagre, but through the efforts of Mr. Ed Newton of Monticello, Ind., I am able to cite a few definite historical accounts.

Historical Sketch of the Sawmills of White County.

In 1830 Joseph Rothrock built a brush dam across the Tippecanoe River at Tioga, south of Monticello, and installed a sawmill, which was probably the first mill built in White County. It never amounted to much and its location is now only a memory.

A Norwegian, Hans Erasmus Hiorth, bought a thousand-acre tract of land in 1832 and laid out the town of Norway, north of Monticello. He built a timber dam across the Tippecanoe, set up two sawmills and operated them by power obtained from the dam. They were run very successfully for many years, but have now been dismantled for over a third of a century.

In 1848 a dam was built across the Tippecanoe at Monticello and in the following year Zebulin Sheetz built the first sawmill in Monticello, operating it with power obtained from the dam. A second mill was built later by Hoagland & Conklin. Both of these mills have been dismantled for some forty years and their very location is forgotten.

In 1882 W. E. Meyers built a steam sawmill at Idaville, capable of cutting from 6,000 to 8,000 feet of lumber per day. This mill was run for several years very successfully, but has gone the way of all the preceding.

Definite history for a mill operated by the Wrights along the Tippecanoe between Monticello and Buffalo was not available.

At present there are a number of portable sawmills distributed over the county. These are operated by thrashing-machine engines and their owners will locate wherever there is 10,000 feet or more of timber to cut.

The only active stationary mills coming to my knowledge are those of Pierce & Son at Burnettsville and that of John H. Knickerbocker at Monticello. The Pierce mill has been running for several years, but the latter, which uses electric power, was started only last summer. But very little of the material cut at either mill is shipped, most of the lumber being used in the immediate vicinity.

The lumber concerns of Monticello report no sales of native timber for a number of years. This is also true for concerns in Idaville and Brookston. The Colborn-Dye Company of Wolcott, however, in looking over their files for the past five years, find the following statistics:

TABLE III.

White County Oak Bought and Sold by the Colborn-Dye Company of Wolcott.

1911	25,100 feet.
1912	8,878 feet.
1913	7,858 feet.
1914	22,622 feet.
1915	11,813 feet.
Total	76,271 feet.

"We have probably had 3,000 to 4,000 feet from our local people, which is not included in the above. The figures given above are all for oak timber shipped from Burnetts Creek."

Several carloads of walnut were shipped from Monticello in the spring of 1915.

Messrs. Reed, Spencer & Wright of Wolcott have bought and are cutting for shipment a quantity of white oak east of Monticello.

The figures for a mill near Reynolds, covering four active years, are as follows. (Thomas Lemon.)

TABLE IV.

	1907.	1908.	1912.	1914.	Total.
Feet of lumber	51,704	63,490	76,819.	6,345	198,358
Cords of wood	719	1,158	....	211	2,086
Railroad ties	....	3,159	4,906	583	8,648
Fence posts	....	....	3,501	....	3,501

A reply from Brookston (M. B. Yount) enumerates various cuts of lumber aggregating 51,000 feet, as follows:

TABLE V.

7,000 feet 1-inch board finishing lumber @ $30-$50 per 100 feet.
15,000 feet 2½-inch bridge plank @ $30 per 100 feet.
7,000 feet 1-inch boards @ $25 per 100 feet.
22,000 feet of 2 x 4 and 2 x 6, 8, 10, 12, 14, 16 feet long, @ $25.
All oak—some white oak, little black oak, remainder red oak. (1915.)

TABLE VI.

Jacob Dieter of Reynolds reports:
5,000 railroad cross-ties.
245,000 feet of lumber.
5,000 fence posts.
All black and white oak.

Mr. Wm. F. Prall has done much cutting on the Bunnell estate near Reynolds and reports the following figures for the period of September, 1915, to March, 1916:

TABLE VII.

10,000 railroad cross-ties.
25,000 feet of lumber.

In nearly this same time he has cut 200,000 feet of lumber in Carroll County just across the White County line.

The reports from the above five sources make a grand total of 574,129 feet of lumber, 43,648 railroad cross-ties, 8,501 fence posts and 2,086 cords of wood. Other mills in the county will show as high and possibly higher figures. Besides the output of these portable mills using up native timber there is, speaking comparatively, a considerable amount of timber cut up as cord wood and fence posts. The supply is becoming less and less each year, and were the county at once deprived of all the timber now left, the lack of this valuable resource still remaining, I am sure, would be keenly felt.

Much timber land has been cleared for agricultural purposes and this work is still in progress. Very often parties have been so anxious

to clear a section that timber was given away for the work of its removal. Practices in clearing have often been very wasteful. I mention this with the very contrasting idea in mind of how governments and foresters are taking every precaution to conserve the rapidly diminishing forests by preventing and controlling fires, insect and fungous pests. Man seems to enter as the most destructive agent of all, not alone by being merely uneconomical but by lacking judgment in making cause for erosion, or perhaps denuding, a place entirely unfit for any other purpose. Forest management and care of trees generally is almost entirely unknown in White County, as it doubtless is in many other counties of the State. Further than that, any admonition to take care of the forests would seem absurd to most citizens. And yet some have seen fit to set out little groves of the much heralded but rather overrated catalpa. White County is an integral part of the hardwood area of the country and as such merits its share of attention.

Below is given a summary covering some interesting features taken from a report of the Department of Labor and Commerce, Bureau of Corporations (The Lumber Industry, Part I, Standing Timber, Jan. 20, 1913). Figures for White County in comparison with the following data are not available. Those acquainted with the area or any other part of the State may draw their own conclusions.

The total amount of standing timber in the continental United States, suitable for the manufacture of lumber under present standards in the industry, is about 2,800 billion board feet, of which 2,200 billion, or 78%, is privately owned. (Unit is the board foot, which is 1 foot square and 1 inch thick.)

The present (1913) commercial value of the privately owned standing timber is about $6,000,000,000, and is becoming more and more valuable. The yearly drain on saw timber is about fifty billion board feet. Only fifty-six years' supply remains.

TABLE VIII. COMPARISONS OF CUT OF LUMBER BY SPECIES.*

SOFTWOODS.

	United States.	Indiana.	Illinois.	Ohio.	Michigan.
Active mills reporting	48,112	1,604	827	1,632	1,323
Total lumber cut	44,509,761	556,418	170,181	542,904	1,889,724
Yellow pine	16,277,185	....	....	....	....
Douglas fir	4,856,378	....	....	....	....
White pine	3,900,034	64	153	203	258,080
Hemlock	3,051,399	432	....	8,415	614,622
Spruce	1,748,547	....	....	78	21,797
Western pine	1,499,485	....	....	....	....
Cypress	955,635	....	4,186	....	....
Redwood	521,630	....	....	....	....
Balsam fir	108,702	....	....	....	9,645
Cedar	346,008	595	30	16	17,647
Larch	204,022	....	....	....	....
Tamarack	157,192	....	152	48	44,956
White fir	89,318	....	....	....	....
Total softwood	33,896,959	1,216	4,521	10,389	996,747

TABLE IX.

HARDWOODS.

	United States.	Indiana.	Illinois.	Ohio.	Michigan.
Oak	4,414,457	228,343	101,279	259,410	40,023
Maple	1,106,604	43,644	7,163	43,852	543,214
Yellow poplar	858,500	29,174	3,628	42,317	....
Red gum	706,945	23,649	9,748	2,194	....
Chestnut	663,891	2,789	....	16,424	....
Beech	511,244	98,729	1,472	49,421	111,340
Birch	452,370	1,216	475	856	64,341
Basswood	399,151	13,917	587	16,007	69,453
Elm	347,456	40,364	12,102	33,182	58,321
Cottonwood	265,600	4,143	3,939	2,944	6,384
Ash	291,209	23,488	2,894	25,753	24,865
Hickory	333,929	23,513	11,095	21,774	1,850
Tupelo	96,676	262	764	....	....
Walnut	46,108	7,669	5,051	8,580	184
Sycamore	56,511	11,003	5,073	5,243	749
Cherry	24,594	1,969	163	2,105	1,587
All others	37,557	1,330	227	2,453	666
Total hardwood	10,612,802	555,202	165,660	532,515	922,977

*Table 18, pp. 88, 89, 90, 91, 92. Department of Commerce and Labor, Bureau of Corporations. The Lumber Industry, Part I, January, 1913.

TABLE X.

Indiana ranks 26th in total lumber cut in the United States.

Indiana ranks 9th in hardwoods cut.

Indiana is a poor last in softwoods cut. (Illinois next.)

The greatest softwood States in the Union in order are: Washington, Louisiana, Mississippi, Texas, Oregon, North Carolina, Alabama, Minnesota, Virginia, Wisconsin, Arkansas, Georgia, California, etc.

The greatest hard wood States in the Union in order are: Tennessee, Michigan, West Virginia, Kentucky, Arkansas, Pennsylvania, Virginia, Wisconsin, Indiana, Ohio, Missouri, Mississippi, North Carolina, etc.

TABLE XI.

Indiana ranks	9	in Oak.
	7	in Maple.
	7	in Yellow Poplar.
	7	in Red Gum.
	15	in Chestnut.
	2	in Beech. (Mich. first.)
	14	in Birch.
	7	in Basswood.
	3	in Elm. (Wis., Mich.)
	12	in Cottonwood.
	5	in Ash. (Ark., Wis., O., Mich.)
	5	in Hickory. (Tenn., Ark., Ky., Mo.)
	14	in Tupelo. (La., Va.)
	2	in Walnut. (O., Ind., Ky., Tenn. Supply very short.)
	1	in Sycamore. (Ind., Mo. close second. Ark. poor third.)
	5	in Cherry. (W. Va., Pa., N. Y., O., Ind.)
	9	in all others. (Ky. big first.)

TABLE XII.

Number of Indiana Sawmills, Grouped According to Output.

Total sawmills	1,599	1,000- 2,500 M	80
Less than 50 M	195	2,500- 5,000 M	26
50- 500 M	1,121	5,000-10,000 M	3
500-1,000 M	173	10,000-15,000 M	1

The pioneers in White County used much timber for log houses, fuel, and rail fences. Much is still used for house and barn sills, bridge stringers and planks. Fence posts and corner braces, with wire, have

long ago taken the place of rail fences, although one can still find some rail fences in existence. Old settlers tell of much wood being formerly used as fuel by the railroads at their inception. For domestic use wood is still the chief fuel in the county. Formerly most fuel wood was cut in "full cord wood" length, now it is nearly all cut in "block wood" length. Not much pole wood is sold. So far as I know, very little White County timber gets to manufacturing establishments.

VI. SUMMARY.

With the completion of this thesis it is not meant that the final word on Trees of White County has been said. More observation is necessary to complete ranges within the county, and more material is necessary to determine some species definitely. Very likely a few species have escaped observation.

Sixty-two out of 125 trees reported for the State have been found in White County; 17 small trees or large shrubs are noted, in addition to two new varieties for the State.

The likelihood of a new willow and a new thorn for the State are mentioned. A new variety of willow is also reported.

The peculiar oak found northeast of Brookston needs further investigation, as do all of the above, and other species as well.

Lack of time has precluded further data being included.

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